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STUDIES ON MARINE BRYOZOA. IX. *PHYLACTELLIPORA*

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The purpose of this paper is to: 1. report the occurrence of *Phylactellipora lyrulata* (Calvet) 1909 from new Antarctic localities; 2. fill in several gaps in the morphology of this species, particularly as regards orifice structures, operculum, digestive tract anatomy and skeletal wall; 3. modify the observations of Livingstone on the soft parts, observations which must have been made on polypides that were either dried up or in poor condition; 4. draw attention to the range of variation of structures; 5. bring the synonymy up to date; and 6. add to the ecology of the species.

SYSTEMATICS

Because of the recent erection of a new family Phylactelliporidae and a new genus by Dr. Bassler (1953, p. G217) the present species, heretofore known as *Phylactella lyrulata* Calvet 1909 should be assigned to Bassler's new genus *Phylactellipora*. Its classification therefore is: *Phylactellipora lyrulata* (Calvet) 1909, Family Phylactelliporidae Bassler 1953, Suborder Ascophora Levinsen 1909, Order Cheilostomata Busk 1852.

Family Phylactelliporidae Bassler 1953

Family Phylactelliporidae was established by Dr. Bassler (1953, p. G217) for seven genera which have a "well-developed peristomie bearing a protective organ (lyrula, mucron) for the compensatrix." The chief difference between the Phylactelliporidae and the older family Phylactellidae from which it was split off appears to be the presence of the "protective organ (lyrula, mucron)" in the new family and its absence in the now restricted family Phylactellidae. The status and comprehensiveness of the two families will undoubtedly be changed when some of the genera, particularly *Perigastrella*, and species in the family Phylactellidae Canu and Bassler 1917 are more critically studied by other workers. Time does not permit such digression so it was thought best to put the present species *P. lyrulata* into the new genus and new family and leave the more critical study of family status to subsequent workers.

Genus *Phylactellipora* Bassler 1953

Bassler (1953, p. G217) defines the genus *Phylactellipora* thus: "Zooecia with circular aperture, bearing cardelles and a lyrula. Peristome funnel-shaped, ovicell salient, globular." The type species is given as *Lepralia collaris* Norman 1867 but *Lepralia eximia* Hincks 1860 would have made a more suitable genus than the *L. collaris* because *L. eximia* has a clearly visible lyrula (see figures of both species in Hincks, 1880, pp. 358, 359 and Plate 43, fig. 3; Plate 49, fig. 9). The *P. lyrulata* is closely allied to the *L. eximia* which Hincks moved to *Phylactella* (1879, p. 161) and which Canu and Lecointre (1930, p. 108) shifted to *Perigastrella*. *Lepralia eximia* Hincks 1860 seems to belong in *Phylactellipora*.

Phylactellipora lyrulata (Calvet) 1909

(Figures 1-21)

Synonymy and previous records:

1909. ? *Phylactella lyrulata*. Calvet, p. 32; Pl. III, Fig. 7. Calvet pictured seven non-ovicelled zoecia from frontal aspect. Did not see ovicells. Mentioned lyrula but did not picture it. Had only one small incomplete fragment of colony from which to describe the new species.
1924. *Phylactella lyrulata*. Thornely, pp. 15, 16. Found ovicells but did not picture them nor materially add to the description.
1928. *Phylactella lyrulata*. Livingstone, pp. 73-75; photographs of colonies on Pl. VI, Figs. 1, 2, 6; and Pl. VII, Fig. 1. His text figures 16 and 17 show the inner frontal wall surface, lyrula, compensatrix muscles, oclussor muscles and very dried up polypide. He mentions operculum but does not figure it.
1952. *Phylactella lyrulata*. Vigeland, p. 10. Distribution only.
1956. *Phylactella lyrulata*. Rogick, pp. 226, 267, 300. Mentioned only in connection with other species.

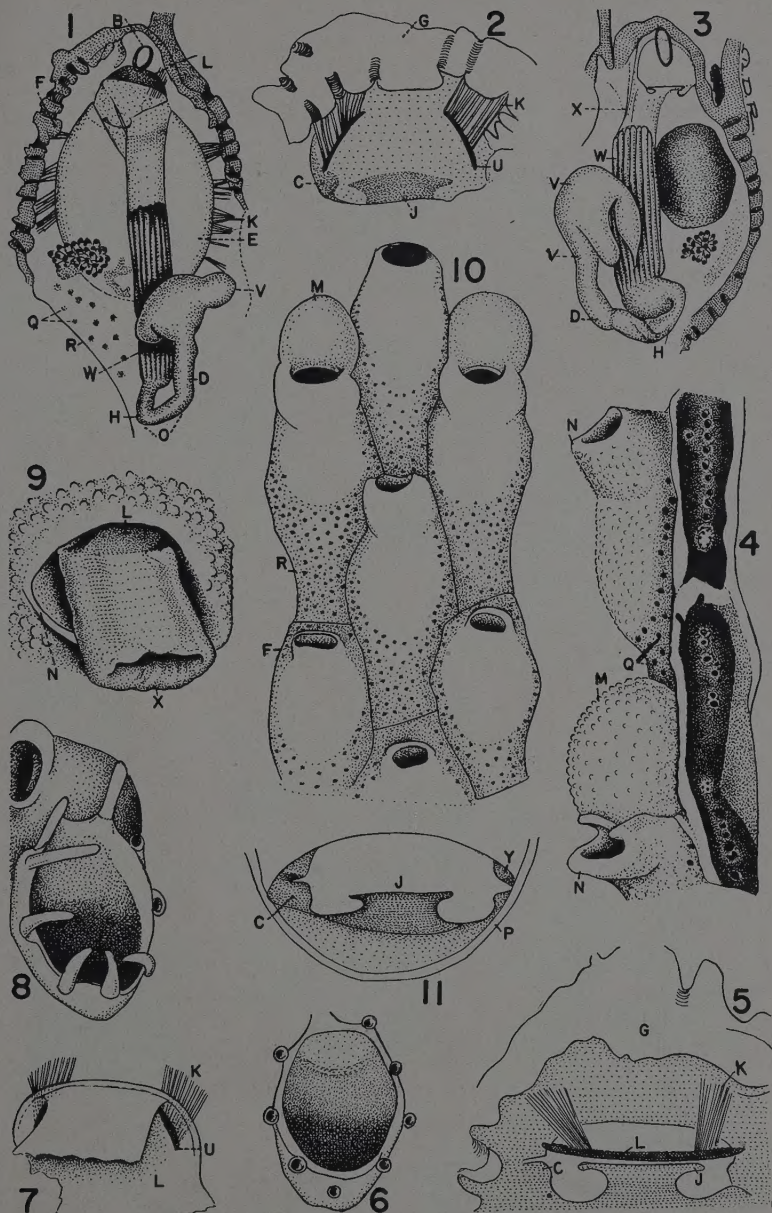
Key to abbreviations used on plates

A—Anus	N—Peristome
B—Basal wall pore	O—Polypide
C—Cardelle	P—Pore chamber in lateral wall
D—Cardia	Q—Stellate frontal pore
E—Compensatrix	R—Proximal-lateral wall
F—Distal-lateral wall	S—Pylorus
G—End wall	T—Rectum
H—Esophagus	U—Sclerite
J—Lyrula	V—Stomach
K—Muscles	W—Tentacles
L—Operculum	X—Tentacle sheath
M—Ovicell	Y—Ledge above cardelles

EXPLANATION OF FIGURES IN PLATE I

All figures on this plate are of *Phylactellipora lyrulata*, drawn with the aid of a camera lucida.

- One zoid, seen from the basal surface, with nearly all the basal wall removed, except in the immediate vicinity of the basal pore (B). Polypide (W,H,O,D,V) withdrawn. Compensatrix (E) attached to the zoecial wall by several groups of parietal muscle fibers (K) around its periphery. The operculum (L) is in characteristic location, very close to the pore. Testicular mass shown to left of tentacles.
- Operculum from the inner, basal aspect. Oclussor muscles (K) attach to sclerites (U) at one end and to zoecial wall at other end. The lyrula (J) is in front of (outside) the operculum.
- Basal aspect of zoid whose body cavity contains an embryo, the large dark ball at right of the tentacles.
- Side view of two zooids, the upper non-ovicelled, the lower with an ovicell. Lateral walls with their communication pores are darkened for contrast. The narrow front rim of the ovicell shows well as does the interruption of the peristome by ovicell.
- Orifice from inner, basal aspect, with the operculum (L) open, at right angles, to the lyrula (J). Orifice appears shorter proportionately than it really is, due to the angle at which it is tipped.
- Ancestrula. Eight spines broken off; ninth not yet developed.
- Operculum. Its lower limit is indefinite. A strip of body wall was torn off with it.
- A 9-spined ancestrula with its budded-off normal-looking zoecium. Two spines broken off.
- Partly extruded tentacular sheath (X) with operculum (L) above it, a location characteristic of this species. Looking down on the peristome.
- Seven calcined zoecia, two ovicelled, the rest not. The non-perforate front below orifice represents the compensation sac area. Pores on lower front stellate.
- Orifice of ovicelled zoid seen from the outside. The cardelles (C), the grooves above them and the ledges (Y) above the grooves are typical but sometimes hard to see. Upper border of inner, primary orifice hidden by ovicell rim.



Diagnosis:—Zoarium partly encrusting. Zooecia large. Frontal a pleurocyst, with varying numbers of rows of stellate peripheral pores arranged in a crescent proximally. Basal wall with large oval distal pore. Lateral walls have 5 to 12 rosette plates or corresponding openings. Compensatrix occupies about half the frontal inner surface. Tubulous flattened peristome longer below than above orifice. Peristome entire except when globose imperforate ovicell is present to interrupt it. Lyrula low, broad, with corners sharply prolonged laterally. Cardelles with groove and ledge directly above them. Delicate, simple, incomplete operculum. Ancestrula 9-spined.

MORPHOLOGY

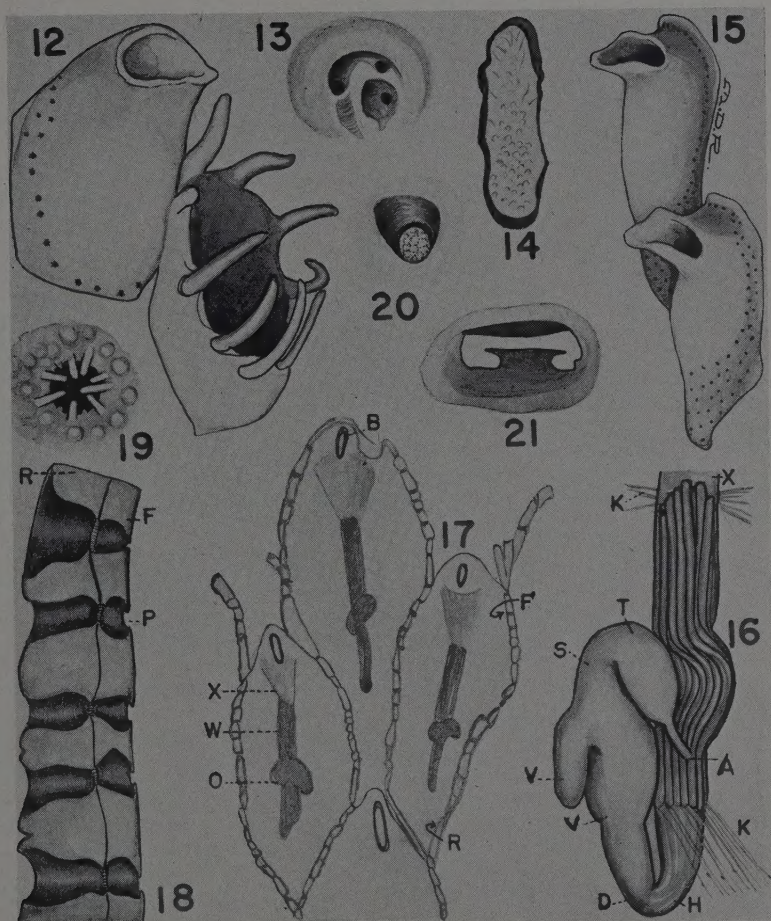
In calcareous bryozoa the external skeleton (zoecium) is sometimes the only part described and even that, most likely, very inadequately. Some of the taxa are founded exclusively on the exoskeleton. Soft internal parts as tentacles, gut, musculature, other organs and sometimes even opercula or other chitinous structures are often completely ignored even if there appears to be sufficient material. In some species the calcareous exoskeleton may be sufficiently transparent in places for the soft parts to show through it, as is the case in *P. lyrulata*, through whose back wall the soft parts can be studied to some extent. In many species, however, one must resort to decalcification or careful dissection and removal of exoskeleton before soft parts can be studied, procedures both time-consuming and resulting in the partial destruction of the specimen. Consequently, the internal anatomy of many recent calcareous bryozoa has never been fully investigated by taxonomists, so there remain many gaps in our knowledge. It is the purpose of the present series of papers to fill in as many gaps as possible for Antarctic species and to show the range of variation of which a species is capable, in so far as material permits.

Variations in size of individuals and structures are the easiest to study and are in some instances significant in differentiation between otherwise similar species. The measurements below give the range of variation for *P. lyrulata*, based on the USNM specimens. Previous authors have given no measurements whatever for this species.

EXPLANATION OF FIGURES IN PLATE II

All figures on this plate are of *Phylactellipora lyrulata*, drawn with the aid of a camera lucida.

12. Nine-spined ancestrula and typical second zoecium of the new colony.
13. Rosette plate with four pores from distal-lateral wall of zoid.
14. Chitinous membrane that plugs up the basal wall pore.
15. Two zooecia with unusually long urceolate peristomes.
16. Withdrawn polypide, tentacles slightly twisted in tentacle sheath. The short muscles (K) at top are the parieto-vaginals, while the lower, longer muscle fibers (K) attached to the lophophore or base of the tentacles are the retractors.
17. The basal surface of four zooecia. The basal wall pore (B) is next to the end wall in all cases. End walls are single, side walls are double partitions between zoids.
18. Detail of a double lateral wall as seen from the basal aspect. The thicker left wall (R), with its deeper channels or openings is the proximal-lateral wall of a left zoid. The thinner right wall, with its shorter, bulb-shaped rosette plates or chambers is the distal-lateral wall of a right zoid. The channels or pores are usually filled with soft parenchymous tissue strands.
19. Detail of a stellate frontal pore, which is generally round internally and partly bridged over externally.
20. Looking down into a communication canal and pore from the proximal-lateral wall. Compare with the side view of similar channels in left wall of figure 18.
21. Peristomie (channel), lyrula, cardelle and the darkened operculum above and parallel with the lyrula. This was the position of the operculum frequently found in zooecia which were empty of polypides, or where degeneration had set in.



Measurements:—The first figures are the minimum, the next the maximum readings; the last, in parentheses, are the average of all readings, 10 for each structure, unless otherwise specified. Length, width and height are abbreviated to L, W and H. All measurements are in millimeters.

1.517–1.924 (1.728)	L Zooecia, frontal view
0.851–1.036 (0.925)	W Zooecia, frontal view
0.144–0.202 (0.169)	L Peristomice (secondary orifice), inside measurement, somewhat foreshortened, as seen from front.
0.259–0.360 (0.296)	W Peristomice, inside
0.144–0.187 (0.167)	L Primary orifice, 3 measurements
0.288–0.360 (0.317)	W Primary orifice, 3 measurements
0.050–0.072 (0.065)	L Lyrula
0.086–0.173 (0.126)	W Lyrula at narrowest point
0.144–0.230 (0.175)	W Lyrula at widest point, tip
0.504–0.634 (0.583)	L Ovicell
0.562–0.590 (0.575)	W Ovicell
0.101–0.259 (0.170)	L Basal wall pore
0.072–0.158 (0.107)	W Basal wall pore
0.147–0.169 (0.159)	L Operculum, 4 readings
0.250–0.279 (0.264)	W Operculum, 4 readings
0.264–0.338 (0.298)	Embryo diameter

Zoarium:—The colony or zoarium may form extensive, brittle, calcareous chips. It may be unilaminar, bilaminar or even trilaminar. It is encrusting to foliaceous, its free edges crinkly. It may grow out in sheets or fronds. Its coarsely patterned surface is rough, like a file, because of the projecting peristomes of the large zooecia. Polypides and embryos are present.

Ancestrula:—The ancestrula looks quite different from the other zooids of the colony, resembling a Membraniporan zooid. It is 9-spined, has a large membranous frontal area and an imperforate gymnocyst surrounding the membranous frontal area. A larva can settle and produce an ancestrula on the frontal face of a living colony of its own species and thus in time give rise to an overgrowing layer of zooids. One zoarium, from Sta. 190, had a young colony of 6 zooids and ancestrula growing on it.

Avicularia:—Absent.

Zooecia:—The pentagonal to heptagonal zooecia (fig. 10) are thin-walled and large enough to see with the unaided eye. Their beaded frontal surface is convex, rising gradually to the urceolate peristome. The central, more elevated part of the front is imperforate. The peripheral part has numerous stellate pores arranged in a crescent proximally, in several rows (4 to 8). Their number diminishes laterally and distally to one or two rows (fig. 15). The pores are round on the inside wall surface but stellate on the outside (fig. 19) because of the delicate spicules jutting out over them.

Inconspicuous, faintly salient mural rims outline some of the zooecia.

The compensation sac (compensatrix) area occupies the inner surface of the non-perforate part of the frontal wall or about one half of the entire frontal (fig. 1). Livingstone described it but apparently did not grasp its significance. Numerous short unilaminar bundles of muscle fibers attach to the compensatrix at the boundary or periphery of the compensation sac area.

The basal wall of the zoecium is smooth, translucent, slightly convex. Near its distal end is a large, oval, membrane-covered hole, which is present in all zooecia (fig. 1, 3, 14, 17). Its chitinated border ranges from colorless to a deep brown. It is strange that a pore so large, constant in position and peculiarly located should have escaped the notice or comments of other workers. Its function is unknown but its location just opposite (directly behind) the orifice suggests that this membrane-covered uncalcified part of the basal wall may be of use in equalizing internal pressures when the tentacles and tentacular sheath are extruded or when being withdrawn into the zoecium.

The end walls are single and sinuous to acutely peaked.

The gently curved lateral walls have 5 to 12 rosette plates or corresponding openings per wall. No attempt is made to distinguish here between rosette plates and openings as defined by Levinsen (1909, pp. 27–28), although figure 18 does show the difference between them. The

rosette plates may be multiporous (fig. 13) or uniporous. They are arranged sometimes in a single row (fig. 4), sometimes in zigzag fashion.

Orifice:—In non-ovicelled zoids the secondary orifice (peristome) is dorso-distal (fig. 4), ellipsoidal, wider than long and completely surrounded by an elevated, beaded peristome which is formed entirely by its own zoecium, *i.e.*, the next distal zoecium does not take part in its formation as is the case in some other species. The peristome is much longer proximally than distally, its lower lip urceolate, sometimes like a pitcher spout (fig. 15). In ovicelled zoids (fig. 4, 10) the peristome is interrupted distally by the ovicell, hence is incomplete. No oral spines present. The ancestrulae (fig. 6, 8, 12) are the only individuals with spines.

The primary orifice is somewhat reniform, deep within the peristome (fig. 2, 3, 5, 11, 21). A sinus separates the broad low lyrula on each side from the ledge-like cardelles. The cardelles were not mentioned by previous workers. Above the cardelles may sometimes be seen a groove and an obliquely slanting ridge. These may escape notice because of their slanting downward and back of the cardelles. The sharp thin corners of the lyrula are sometimes greatly extended laterally over the sinuses, even more so than shown in figure 5. Livingstone pictured the lyrula faithfully but missed seeing the cardelles, groove or overhanging ledge. It is very easy to overlook them.

Operculum:—The delicate, faintly chitin-edged (fig. 7), peculiarly located (fig. 9) operculum is difficult to see. In zoecia empty of polypides the operculum and its part of the body wall may remain attached inside the distal wall of the peristome (fig. 21). In zoecia with partly extruded tentacle sheaths (fig. 9), the operculum is above the tentacle sheath—a position less common than that in other operculate bryozoa where the usual position for the operculum is below or in front of the tentacle sheath.

The operculum is somewhat hemispherical. Its outer curvature is slightly chitinized (fig. 7) but its inner, proximal border is essentially non-delimited. A slender chitinized sclerite is obliquely set some distance in from each lateral border. To it attaches a row of sturdy thickly set opercular (occluser) muscles (fig. 2, 5, 7). So far as can be determined, the opposite ends of these muscles seem to attach near the junction of the lateral, basal and distal walls, but the exact location requires further study. Examination of the fibers with phase contrast did not reveal any striations in the muscle fibers.

Ovicells:—The ovicells are globose, salient, finely beaded, imperforate (fig. 4, 10). The neighboring zoecial fronts do not encroach upon the ovicell, nor do the peristome walls. The latter only meet the ovicell, which interrupts the peristome. Not all zoids had ovicells but ovicells were present in material from most stations. Practically all but a very few were empty of any embryo. More zoid body cavities than ovicells had an early embryo at the time of collection (fig. 3).

Polypide:—The polypide (fig. 16) consists of the tentacles, tentacle sheath, digestive tract and associated musculature. The digestive tract folds up along side the tentacles when the latter are retracted. The tentacle sheath is long, and the anus opens into it. The digestive tract consists of mouth, pharynx-esophagus, cardia, pyloric zone of stomach, coecum (caecum or cul-de-sac) part of stomach, rectum and anus. The pharynx-esophagus is about as long as the cardia but thicker-walled than the rest of the tract. The esophagus, cardia, stomach and rectum are yellow. The tentacular sheath, tentacles, oropharyngeal zone are darker. Retractor muscles attach to the lophophore region at the base of the tentacles. As in the occlusors, no striations could be seen in the fibers under phase contrast but the material was not fixed or specially stained to make sure.

No oral glands are present in the opercular region.

Since nearly all zoids were retracted the tentacle number could not be accurately ascertained, but it did appear to be greater than 12 and less than 20.

Livingstone (1928, p. 73, fig. 16) pictured a polypide but it must have been a dried up specimen because it is rather misleading. However, he is the only predecessor who made an earnest attempt to study the soft parts in this species.

A spermary occurred in both ovicelligerous and non-ovicelled zoids but did not seem to be present in all zoids examined. Whether this is because some zoids may be asexual or whether gonads are only temporary structures could not be determined at this time. Spermaries were

seen in some zoids which seemed in their prime and in other zoecia whose polypides had largely degenerated. A small, lumpy, band-like ovary is present in a few ovicelligerous zoids near the spermary. The spermary is larger, more definite and shaped like a raspberry (fig. 1, 3). It is at the side of the body cavity, near the side wall, some distance away from the digestive tract.

Some ovicelled zoids had a single large developing embryo in the body cavity, in addition to the spermary, so must have been hermaphroditic. As the embryo increased in size the polypide degenerated. No fertile zoid had more than one sizeable developing embryo in it at the same time.

DISTRIBUTION AND ECOLOGY

To date, *Phylactellipora lyrulata* has been collected only from Antarctic localities and from depths ranging between 25 to 354 fathoms (Livingstone, 1928, p. 75). The USNM specimens came from depths of 35 to 58 fathoms, from Antarctic stations Nos. 101, 104, 190, 225, 226, 230, 234, 236 and 243, between Jan. 29 and Feb. 22, 1948. Stations 101 and 104 are off Cape Royds, Ross Island; Stations 190 thru 243 are from Marguerite Bay, Antarctica. For full station data see Rogick (1956, pp. 222-223).

Phylactellipora lyrulata seems to be a species very adaptable to life on or with other organisms, because it is frequently found either growing on some other form or vice versa. Other species grow sometimes on its face, sometimes on its back, on either living or on dead colonies. Some of the bryozoan species which grow on *P. lyrulata* are *Barentsia discreta* (Busk) 1886, from Sta. 190, (Rogick 1956, p. 227); *Beania*, Sta. 234; *Cellepora milleporoides* Calvet 1909, Sta. 234; *Cribrilina spatulata* Calvet 1909, Sta. 236; cyclostomatous bryozoa, Sta. 226, 234, 236; *Lepralia marginata* Calvet 1909, Sta. 225; *Microcorella parvipora* Waters 1904, Sta. 226; *Ramphonotus inermis* (Kluge) 1914, Sta. 226, 234; *Smittina ordinata* (MacGillivray) 1895, Sta. 226 (Rogick 1956, p. 300). Other forms which grow on *P. lyrulata* are both calcareous and mud worm tubes, sponges and hydroids. In turn, *P. lyrulata* was found growing over a calcareous worm tube from Sta. 190, entangled on a starfish from Sta. 243 and on the bryozoans *Cellarinella roydsi* of Sta. 234 (Rogick 1956, p. 267), *Schizoporella tumida* var. *tricuspis* Calvet 1909, Sta. 226 and on other species yet to be identified.

Specimens of *P. lyrulata* are on deposit with the Smithsonian Institution, USNM Cat. Nos. 11347 thru 11350 and 11352.

SUMMARY

1. *Phylactellipora lyrulata* is reported from additional Antarctic localities.
2. Measurements of many structures are given for this species, none having been available heretofore, to show the range of size variation.
3. The peculiarly located operculum is figured fully.
4. Livingstone's description and sketches of the polypide (gut) are modified and augmented.
5. Other species in the present collection incidentally reported from additional Antarctic localities are: *Cellepora milleporoides*, *Lepralia marginata* and *Microcorella parvipora*.

ACKNOWLEDGMENTS

The material on which this article is based is part of the bryozoan collection, USNM Accession No. 177438, lent to the writer several years ago by the Smithsonian Institution, U. S. National Museum, from the U. S. Navy's 1947-48 Antarctic Expedition, Comdr. David C. Nutt collector. Material financial assistance towards it has been received from research grants from the National Science Foundation. Most grateful acknowledgment is made to the foregoing for their extremely generous aid and cooperation.

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- Remaining incidental citations are fully listed in Rogick 1956 "Literature Cited" section, and are not here repeated.

A NEW SPECIES OF *VITELLIUS* FROM THE UNITED STATES (COLEOPTERA: EUCNEMIDAE)

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*Department of Zoology and Entomology, The Ohio State University, Columbus, 10**Vitellius texanus* n. sp.

This is the first record of a member of *Vitellius* Bonv. occurring in the United States.

Cylindrical, robust, convex, slightly narrowed posteriorly, blackish brown throughout with exception of antennae, legs and lateral margin of pronotum which are somewhat lighter.

Head moderately convex, margin of clypeus sinuate; surface finely granulose with median carina extending from vertex nearly to clypeus, pubescence short; antennae pectinate, rami starting with fourth segment, scape stout, slightly excavated on dorsal surface, a fine carina on ventral side, second and third segments short, subequal, slightly broader than long, fourth as long as second and third united, ramus nearly twice length of segment, fifth to eleventh gradually decreasing in length, rami increasing in length to eighth segment, then decreasing, eleventh segment slightly shorter than tenth ramus.

Pronotum slightly broader than long, widest at base; anterior margin broadly rounded; posterior margin sinuate; side margin rounded in front then subparallel to hind angles which are produced forming an obtuse angle; disk convex, flattened in middle, a basal transverse depression each side, a flat transverse rectangular plate in front of scutellum, in front of which is a short depressed line, surface granulose, granules coarser than on head, recumbent pubescence short. Scutellum slightly wider in front than long, rounded posteriorly; surface granulose.

Elytra near base slightly wider than pronotum; sides subparallel in front, then broadly rounded to suture; disk convex, a basal depression each side, short oblique carina under umbone; surface striate, punctures of striae small, interspaces granulose, recumbent pubescence short.

Beneath, abdomen convex, last sternite pointed posteriorly; surface finely granulose, last sternite more coarsely granulose, clothed with short recumbent pubescence. A deep, ventral antennal groove extending full length along lateral margin. Posterior coxae with sides subparallel, widened exteriorly. All tarsi slender, first segment of posterior tarsus longer than the three following segments.



Vitellius texanus n. sp. (Line represents 1 mm.).

Length 4.6 mm.; width 1.7 mm.

Holotype in collection of author, collected March 26, 1954, in Bentsen, Rio Grande Valley State Park, Hidalgo Co., Tex., by D. J. and J. N. Knull.

This species differs from *V. gautardi* Bonv. (p. 790) by having third antennal segment about equal to second and from *V. lafertei* Bonv. (p. 789) by having pronotum wider than long.

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Bonvouloir, H. de. 1870-1875. Monographie de la famille des Eucnémides. Ann. Soc. Ent. Fr., ser. 4, 10: 1-907, 42 pls.

Police Drugs. Jean Rolin. Translated from the French by Laurence J. Bendit. Philosophical Library Inc., New York. 1956. x+194 pp. \$4.75.

Certain drugs have been observed by physicians and psychiatrists to reduce the will of the patient to withhold information, or in other words, to cause him to confess when guilty of crime. The drugs described in this book are scopolamine ("truth serum"), mescaline, the amphetamine group, hashish, cocaine, ether, and the barbiturates. Special emphasis is given to pentothal since it was used in a specific case, described in chapter 4, and resulted in a serious miscarriage of justice in French courts.

The author very clearly sets forth the purposes of this book in the first paragraph of the introduction. He writes as follows, "The moment methods of investigating the unconscious pass from the strictly medical and therapeutic sphere into the forensic, these drugs become prostituted into means of extortion, turn the skill of the expert into the work of a policeman, and destroy all chance of true justice being meted out."

The book is well documented and should be of interest to all who are associated with medico-legal problems.

LOYD E. HARRIS

RELATION OF GEOLOGY TO STREAMFLOW IN THE UPPER LITTLE MIAMI BASIN¹

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Water falling upon the land as precipitation is the prime source of streamflow. The pattern in which this precipitation returns to its source in oceans and lakes is dependent upon many inter-related factors affecting both the precipitation and the physical route of return. For example, precipitation on a completely impervious basin of barren rock would result in sudden runoff and frequent flooding, followed by a rapid decline in the streamflow, with little or no flow in a matter of a few days or even a few hours. On the other hand, a geographically similar basin underlain by thick permeable material would permit the infiltration of much of the precipitation to the ground water reservoir. Immediate surface runoff would be limited only to that portion of precipitation in excess of the infiltration capacity of the basin, and streams in the basin might show relatively small rises followed by lengthy periods in which the flow was maintained by seepage from the infiltrated ground water. The effect of the geology of a basin is thus reflected in its regimen of streamflow. This paper describes the relationship between the geology and streamflow in the Upper Little Miami Basin.

GENERAL HYDROLOGY AND GEOLOGY

The Upper Little Miami River above Spring Valley drains an area of 361 square miles lying principally within Greene and Clark Counties. Its topographic location is shown on figure 1. Continuous records of streamflow are available at five sites in the basin, and are among those collected and published by the U. S. Geological Survey in annual water supply papers. Locations of these sites are also shown on figure 1. Geological data are from a report on the Water Resources of Greene County by the Ohio Division of Water (Norris *et al.*, 1950), which includes sections on the geology of glacial deposits by Goldthwait, and on the geology of consolidated deposits by Norris. A series of miscellaneous streamflow measurements made by the U. S. Geological Survey within the basin on September 15, 1948, also is available.

The relation of ground water and geology is well discussed by Meinzer (1923), Tolman (1937) and others. The relation between streamflow and ground water has been studied by many different methods. Cross (1949) used a dry-weather index determined from duration of flow in Ohio streams, for correlation with ground water and geology. The discharge equaled or exceeded 90 percent of the time for the period of record was selected by Cross as an index of dry-weather flow. In this paper, the index of dry-weather flow was selected as the discharge equaled or exceeded 90 percent of the time for the period October 1953 to September 1955.

Duration curves for the period October 1953 to September 1955 were prepared by arranging all daily discharges in order of magnitude and computing the percentages of time that specific flows were equaled or exceeded. This has been done for the five streamflow stations in the Upper Little Miami Basin. The duration curve for Spring Valley for the same period was estimated on the basis of records from 1926 to 1935 and from 1940 to 1951. The resulting duration curves are shown on figure 3. The discharge at the 90 percent duration points, or lowflow indices, from these curves also are shown on figure 1. The shape of the lower end of the duration curves is indicative of the degree to which streamflow is sus-

¹Publication authorized by the Director, U. S. Geological Survey.

tained by effluent seepage from the ground water reservoir during periods of no surface runoff. This effluent seepage in turn can be related to the lithology and structure of the rocks which control the infiltration to and transmissibility of the ground water reservoir.

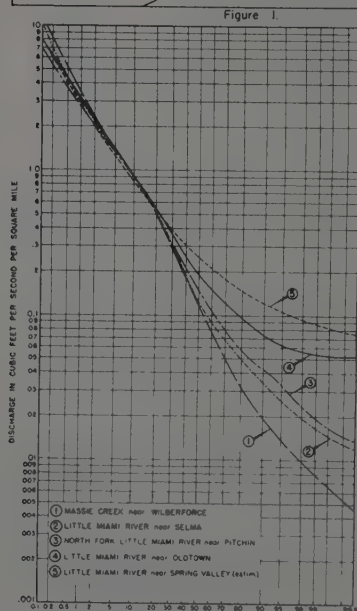
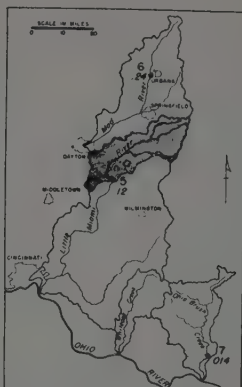
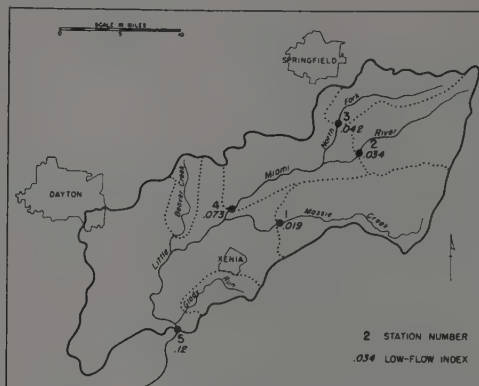


Figure 3.

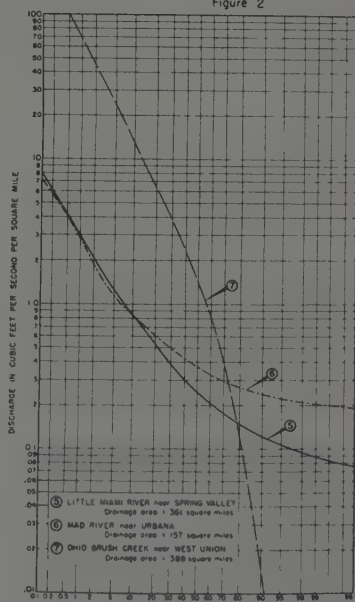


Figure 4.

FIGURE 1. Upper Little Miami basin.

FIGURE 2. Little Miami and adjacent basins.

FIGURE 3. Flow durations, 1953-55, for Upper Little Miami basin.

FIGURE 4. Flow durations, 1953-55, for selected Ohio streams.

The geology of the Little Miami Basin is fairly consistent in its pattern. The consolidated rocks consist chiefly of limestones and dolomites of the Niagara group of the Silurian system which form the bedrock underlying the glacial drift. The formations crop out in several places, most notably near Cedarville, and in the groups near Clifton and Yellow Springs. Overlying the bedrock is glacial drift of varying thickness deposited by the Wisconsin ice sheet of Pleistocene time. These glacial deposits were laid down chiefly as ground moraine, kames, outwash plains, and valley-train deposits. It is the variations in these glacial deposits that have the most pronounced effect on the pattern of sustained streamflow in the basin.

RELATION OF GEOLOGY TO STREAMFLOW

The lowest sustained flows in the Upper Little Miami Basin during the period October 1953 to September 1955 were in Massie Creek which drains an area chiefly of ground moraine consisting of relatively impermeable clay till of varying thickness over-lying and sealing the consolidated rocks of the Niagara group. The geology is reflected in the low-flow index of 0.019 cfs per square mile for Massie Creek near Wilberforce and is equivalent to an average of about 12,000 gallons per day from each square mile of area in the basin. In the extreme upper reaches of the Little Miami River, flow is sustained by seepage from some outwash deposits and kames, along with that from scattered gravel lenses in the glacial till. This situation is reflected in the low-flow index of 0.034 cfs per square mile for the streamflow station near Selma, and 0.042 cfs per square mile for the streamflow station on the North Fork near Pitchin. These flows are roughly twice that in the Massie Creek Basin. Below these stations, the Little Miami River traverses an area of outwash plains above Clifton, and enters a reach of extensive valley train deposits starting about 5 miles upstream from the streamflow station near Oldtown. At that station, the low-flow index has increased to 0.073 cfs per square mile, or about double that of the upstream reaches above Pitchin and Selma. Also contributing to this high sustained flow are the numerous springs occurring at the top of the Osgood and Massie shales, the Springfield and Brassfield limestones, and the Cedarville dolomite which crop out in the area. The most prominent of these springs is Yellow Spring which issues from a fissure in the Cedarville dolomite. The flow of this spring was measured by Bennison (1942) as 60 to 81 gallons per minute during the period June 1941 to May 1942.

Below Oldtown, Massie Creek joins the Little Miami River, and the river continues to traverse the thick valley-train deposits. Outwash plains of considerable extent also sustain the streamflow in this region, particularly in the Beaver Creek Basin, where the low-flow index in September 1948 was determined as 0.38 cfs per square mile, an extremely high figure for Ohio. At the same time, the flow index for Glady Run just above Spring Valley was determined as 0.42 cfs per square mile from an area consisting predominantly of kames, kame moraines, and out-wash plains. The effect of the high sustained flows from Glady Run and Beaver Creek is reflected in the flow duration curve for Little Miami River near Spring Valley. The low flow index for this site is 0.12 cfs per square mile, and is among the highest indices in the State for areas of comparable size. This flow is equivalent to an average flow of more than three-quarters of a million gallons per day from each square mile of drainage area.

COMPARISON WITH OTHER AREAS

For a general comparison of the Little Miami Basin with extremes for Ohio, flow duration curves have been computed for Mad River at Urbana and Ohio Brush Creek near West Union. The location of these basins is shown on figure 2, and the flow duration curves on figure 4. The sustained flow of the Mad River

above Urbana occurs from the very extensive gravel deposits throughout the entire basin. The low-flow index at Urbana of 0.24 cfs per square mile is just twice that of the Little Miami River at Spring Valley. This extensive capacity for storage of ground water has been estimated by Cross (1949) as equivalent to a surface reservoir from one to one and one-half times the size of Indian Lake. Ohio Brush Creek, in the southern part of the State, drains an area principally of Illinoian till, and is typical of streams draining relatively impermeable soils. These two curves are indicative of the extremes of flow regimen for Ohio.

The streamflow data cited represent a period of extremely low flow. For example, the low-flow index for the period 1953 to 1955 is 0.24 cfs per square mile for the Mad River at Urbana, whereas for a total period of record of 15 years at this station the low-flow index is 0.33 cfs per square mile. This difference, although quantitatively significant, has an almost negligible effect so far as general comparisons of streamflow regimen are concerned.

SUMMARY

1. The variation in low-flow indices for streams in the Upper Little Miami Basin is controlled principally by the variations in the glacial geology of the area. 2. In general, the magnitude of sustained flow from effluent seepage can be related to the extent of glacial gravels in the basin. 3. Sustained flows in the basin ranged from 0.019 cfs per square mile to as high as 0.42 cfs per square mile in different sub-basins. 4. The Little Miami River has a favorable regimen of sustained flow when compared with other Ohio streams. It is exceeded in Ohio only by the Mad River Basin adjacent to the north and east.

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General Zoology. David F. Miller and James G. Haub. Henry Holt and Company, New York. 1956. viii+550 pp. \$6.75.

This well illustrated introduction to zoology handles the usual information in a refreshing manner. For the most part each principle of general zoology is brought out by use of the scientific method in analyzing data which are presented in the text. The student is encouraged to use similar methods in solving problems he may encounter outside of the classroom. The text is so arranged that the exploration of one life process leads to questions concerning other processes which are discussed in succeeding chapters. Because of this carry-over from one chapter to another and the continual application of the scientific method, the continuity of the text is very good, and reader interest should be well maintained. The presentation of topics is designed to take advantage of the students' interests.

As a text which is used in close integration with lecture or discussion periods, it should be more than adequate. In courses where the text is used as a reference, or where more than two quarters are spent in general zoology, the amount of information imparted may not be sufficient to take care of the more advanced students. The illustrations are all new, which in itself is a refreshing change, and their general quality is excellent. Animal structures are well handled in the illustrations but diagrams of functional processes are not as numerous as in some contemporary texts. This book will find a welcome place in many courses which are using the problem centered approach, and certainly should be used as supplementary reading in all general zoology courses. The introductory chapter on the use of the scientific method should be required reading for all students of biology.

JEFF SWINEBROAD

MOSS COLLECTIONS FROM SOUTHEASTERN OHIO¹

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Since the spring of 1953 bryophytes have been collected extensively in the region of Southeastern Ohio centering around Athens. The rich floras of Vinton, Morgan and Washington Counties were within the range of the collections; however, it is mostly with the poorly worked area of Athens County that the writer is concerned here. The recent study has been done with the close cooperation of Gustav W. Hall who undertook the study of the liverwort flora which he intends to present separately. Both recent collections and those of previous workers (McCleary, 1945) are considered in an effort to list all species known from the area at present.

The region studied consists of unglaciated hill country drained mostly by the Hocking River. The county is rather uniform in topography with slightly more dissection on the western edge. The factors affecting the distribution of species are primarily local. Areas visited included a wide variety of habitats, the most interesting of which were the moist ravines, wet pastures, and one forest in particular, a conifer planting located near Carbondale which contained many distinctive plants (Porter, 1956). Collections included mostly terrestrial and saxicolous forms with a very limited aquatic representation and epiphytic species usually restricted to very moist habitats.

At present the new inroads of strip mining are partly offset by the establishment of parks and preserves in numerous areas. However, none of the existing undisturbed areas appear to have been in development more than a few decades. As further development occurs invasion by other species is probable.

The number of species at present listed for Athens County equals 133. A review of available literature (Conard, 1945a; Emmitt, 1950; Henderson, 1927, 1929, 1930a, 1930b; Schnoorberger and Wynne-Hillier, 1954; Walters, 1952; Wareham, 1941a, b), and a visit to the herbarium of The Ohio State University revealed no previous reports for the state of *Sphagnum fimbriatum*, *Bryum bicolor*, *Pohlia delicatula* and *Brachythecium starkeri*. Except where stated specimens are deposited in the herbarium of Ohio University. Those other than the writer furnishing extensive collections were Gustav Hall and James A. McCleary. Additional specimens were contributed by many others including: W. G. Gambill, A. H. Blickle, S. G. Boyce, Walter Porter, R. T. Wareham. A number of publications (Andrews, 1913; Conard, 1944; Grout, 1903, 1928-40; Jennings, 1951; Welch, 1943-54) were used for identification, and numerous doubtful specimens were identified or verified by Dr. Henry S. Conard, Dr. A. J. Sharp and Dr. Winona H. Welch whose aid the writer wishes gratefully to acknowledge.

SPHAGNACEAE

Sphagnum capillaceum (Weiss) Schrank. Found in one hollow in Carbondale Forest and on an old pine covered slope in Waterloo Game Preserve.

Sphagnum fimbriatum Wils. Found once in another hollow in Carbondale Forest. Previously unreported for the state. Common to the north of Ohio and in the mountains to the east.

TETRAPHIDACEAE

Tetraphis pellucida Hedw. Common on moist shaded rock faces in ravines. Also occasionally on rotten wood.

¹Contribution from the Botanical Laboratory of the University of Tennessee, N. Ser. 175. Most of this work was done while the author was a student at Ohio University, Athens, Ohio.

POLYTRICHACEAE

- Atrichum angustatum* (Brid.) Bry. Eur. Common on soil of higher and more exposed slopes.
Atrichum undulatum (Hedw.) Beauv. Common on moist shaded lower slopes and in bottomlands.
Pogonatum pensilvanicum (Hedw.) Paris. Common on bare soil in moist shaded ravines.
Polytrichum commune Hedw. Scattered, in wet hollows and in patches on cinders along railroad tracks. In a roadside ditch at Lake Hope in Vinton County.
Polytrichum juniperinum Hedw. Scattered, on upper slopes and ridge tops.
Polytrichum ohioense Ren. & Card. Very common on wooded slopes.
Polytrichum piliferum Hedw. Collected once in Athens County on dry wooded south facing slope. Found also on exposed ledge near Moonville in Vinton County.

BUXBAUMIACEAE

- Diphyscium foliosum* (Hedw.) Mohr. Common on shaded slopes and in large patches on moist sandstone.

FISSIDENTACEAE

- Bryoxiphium norvegicum* (Brid.) Mitt. Rare, in a few very sheltered ravines on moist sandstone. Listed from many neighboring counties in southeastern Ohio (Steere, 1937).
Fissidens cristatus Wils. Not common, but in large mats on wet sandstone.
Fissidens minutulus Sull. Common on moist shaded sandstone in ravines. Often hidden by overstory of larger mosses.
Fissidens osmundioides Hedw. Common on soil and rock in moist shaded ravines.
Fissidens taxifolius Hedw. Less common than the last but in similar locations.

DITRICHACEAE

- Ceratodon purpureus* (Hedw.) Brid. Not common but growing on a wide variety of substrates.
Ditrichum lineare (Sw.) Lindb. On shaded soil. Collected in previous study by McCleary.
Ditrichum pallidum (Hedw.) Hampe. In Athens County on shaded soil and uncommon. Wide spread in central Vinton County.
Pleuridium subulatum (Hedw.) Lindb. Common on moist exposed soil in early spring.

DICRANACEAE

- Brothera leana* (Sull.) C. Mull. Rare, collected once on rotten wood in Carbondale forest.
Dicranella heteromalla (Hedw.) Schimp. Common on shaded soil and moist rock surfaces.
Dicranella varia (Hedw.) Schimp. Collected twice at widely separated stations, both times on soil on roadside bank.
Dicranum condensatum Hedw. In extensive patches on shaded slopes near western edge of Athens County.
Dicranum flagellare Hedw. Scattered, on shaded rocks and rotten wood.
Dicranum fulvum Hook. Very common on shaded rocks on north facing slopes and in ravines.
Var. *viride* (Sull. & Lesq.) Grout. Scattered, on tree bases in moist woods.
Dicranum montanum Hedw. Common on moist tree bark.
Dicranum scoparium Hedw. Very common on wooded slopes.
Dicranum spurium Hedw. On shaded slopes in central Athens County.
Leucobryum albidum (Brid.) Lindb. Collected once on rocky, oak covered, south facing slope.
Leucobryum glaucum (Hedw.) Schimp. Very common on shaded slopes.
Rhabdoweisia denticulata (Brid.) Bry. Eur. On moist sandstone in shaded ravines.

GRIMMIACEAE

- Grimmia apocarpa* Hedw. Very common on rock.
Hedwigia ciliata Hedw. Very common on rock.
Ptychomitrium incurvum (Muhlenb.) Sull. Collected many times on partially exposed rock.

POTTIACEAE

- Acaulon rufescens* Jaeg. Collected once on patch of bare soil on grazed slope in early spring.
Astomum muhlenbergianum (Sw.) Grout. Common in early spring in pastures.
Barbula unguiculata Hedw. Very common on roadside banks, preferring more basic soil.
Desmatodon porteri James. Common on walls in Athens.
Gymnostomum aeruginosum Smith. Found in many moist shaded ravines near Athens. Also found near Cutler in Washington County.
Phascum cuspidatum Hedw. Widely distributed in early spring in fields and at roadsides.
Tortella humilis (Hedw.) Jennings. On shaded walls and on tree bases. Not common.
Weissia controversa Hedw. On rocks, soil and some on rotten wood. Common.

EPHEMERACEAE

- Ephemerum spinulosum* Schimp. One collection from a bottomland pasture in October. Probably more common.

FUNARIACEAE

- Aphanorhegma serratum* (Hook. & Wils.) Sull. Widely distributed in bottomland fields in late fall.
Funaria flavicans Mx. Scattered. When immature hard to distinguish from next.
Funaria hygrometrica Hedw. Common on walls and in burned areas.
Physcomitrium turbinatum (Mx.) Brid. Very common on wet soil in fields.

ORTHOTRICHACEAE

- Drummondia prorepens* (Hedw.) Jennings. Collected once on bark of an isolated tree.
Orthotrichum stellatum Brid. Common on fallen logs in moist hollows.
Orthotrichum strangulatum Schwaegr. Found only on cement walls.
Ulota crispa (Hedw.) Brid. On fallen logs in moist ravines. Not common.

AULACOMNIACEAE

- Aulacomnium heterostichum* (Hedw.) Bry. Eur. Common on moist shaded, usually north facing slopes.
Aulacomnium palustre (Web. & Mohr) Schwaegr. Scattered, in boggy places.

BARTRAMIACEAE

- Bartramia pomiformis* Hedw. Common in association with *Aulacomnium heterostichum*.
Philonotis longisetata (Rich.) E. G. B. Scattered, in crevices of rocks in streams.

BRYACEAE

- Bryum argenteum* Hedw. Very common on soil and rock and on overturned tree bases.
Bryum bicolor Dicks. Collected only on a wall on a shaded hillside of the Ohio University campus in Athens. More common southward and previously unreported from Ohio.
Bryum caespitium Hedw. Common on moist shaded rocks.
Bryum capillare Hedw. Common in bottomland fields.
Bryum pseudotriquetrum (Hedw.) Schwaegr. Scattered, in wet places. Collected by McCleary.
Leptobryum pyriforme (Hedw.) Schimp. At bases of shaded, wet cliffs and collected once in fruit on a wall. Not common.
Pohlia delicatula (Hedw.) Grout. (*Pohlia carnea* Linb.) Collected once in a roadside ditch. Scattered in distribution in eastern North America with reports from Illinois and New York. (Grout, 1928-1940), Iowa (Conard, 1945b), Tennessee (Clebsch, 1947), Nova Scotia (Erskine, 1950) and New Jersey (Lawton, 1951). Not previously reported from Ohio.
Pohlia nutans (Hedw.) Lindb. Common on wooded slopes.
Pohlia wahlenbergii (Web. & Mohr) Andrews. On wet soil in shaded ravines. Scattered.
Rhodobryum roseum (Bry. Eur.) Limpr. In moist shaded ravines. Not common.

MNIACEAE

- Mnium affine* Bland. In moist shaded ravines. Not common.
Mnium cuspidatum Hedw. Very common in moist shaded places.
Mnium punctatum Hedw. Common in moist shaded ravines.
Mnium serratum Brid. Common on moist shaded rock surfaces in ravines.

HYPNACEAE

- Amblystegium serpens* (Hedw.) Bry. Eur. Collected once in crevices of a shaded wall.
Amblystegium varium (Hedw.) Lindb. Very common on stones and rotten wood.
Brachythecium flagellare (Hedw.) Jennings. On moist shaded rock in ravines. Not common.
Brachythecium flexicaule Ren. & Card. Collected once in a boggy hollow containing *Alnus* and *Cephalanthus*.
Brachythecium oxycladon (Brid.) J. & S. Very common in moist shaded locations. Mostly on rock.
Brachythecium rivulare Bry. Eur. Common on wet shaded rock in ravines.
Brachythecium rutabulum (Hedw.) Bry. Eur. On rotting wood in moist shaded ravines. Not common.
Brachythecium salebrosum (Web. & Mohr) Bry. Eur. Common in moist shaded locations, usually on rotting wood.
Brachythecium starkei (Brid.) Bry. Eur. One collection on soil in ravine. Not previously reported from Ohio.
Brotherella recurvans (Mx.) Fleisch. Collected only in Carbondale forest.
Bryhnia graminicolor (Brid.) Grout. On moist rock in ravines. Not common.
Bryhnia novae-angliae (Sull. & Lesq.) Grout. A collection located in the herbarium of Ohio State University.
Calliergonella schreberi (Bry. Eur.) Grout. Collected once on moist shaded roadside bank.
Campylium chrysophyllum (Brid.) Bryhn. Common on rather open slopes.
Campylium hispidulum (Brid.) Mitt. Collected once by shaded tree base.
Cirriphyllum boscii (Schwaegr.) Grout. Very common on moist soil and rock in fields and ravines.
Climacium americanum Brid. Common on moist shaded slopes.
Entodon cladorrhizans (Hedw.) C. Mull. On rotting wood in ravines. Not common.
Entodon seductrix (Hedw.) C. Mull. Very common on wood and rock in moist shaded places.
Eurhynchium hians (Hedw.) J. & S. Scattered on soil and litter in moist ravines and roadside ditches.
Eurhynchium pulchellum (Hedw.) Jennings. In moist shaded ravines. Not common.
Eurhynchium serrulatum (Hedw.) Kindb. Common on soil, usually by tree bases.
Heterophyllum haldanianum (Grev.) Kindb. Found once in moist shaded ravine.
Homomallium adnatum (Hedw.) Broth. Collected on moist shaded rocks. Probably common.
Hygroamblystegium tenax (Hedw.) Jennings. Common on rock in small streams.
Hylocomium brevirostre (Beauv.) Bry. Eur. Collected once in a moist shaded rocky hollow.
Hypnum curvifolium Hedw. Common on moist shaded rock.
Hypnum imponens Hedw. Very common on soil on slopes and rotting wood in ravines.
Hypnum molluscum Hedw. On moist soil and rock. Scattered.
Hypnum patientiae Lindb. Common in wet hollows and roadside ditches.
Leptodictyum riparium (Hedw.) Warnst. Collected in shaded stream.
Leptodictyum trichopodium (Schultz) Warnst. var. *kochii* (Bry. Eur.) Broth. Common on moist soil in fields.
Plagiothecium denticulatum (Hedw.) Bry. Eur. Common on moist shaded rocks in ravines.
Plagiothecium deplanatum (Sull.) Grout. On moist shaded rocks in ravines. Scattered.
Plagiothecium geophilum (Aust.) Grout. Collected by McCleary in previous study.
Plagiothecium muellerianum Schimp. On moist shaded rock surfaces in ravines. Not common.
Plagiothecium roeseanum (Hampe) Bry. Eur. On moist shaded rocky bluffs.
Plagiothecium sylvaticum (Brid.) Bry. Eur. Collected in previous study by McCleary.
Platygyrium repens (Brid.) Bry. Eur. Very common on moist tree trunks and fallen logs.

- Porotrichum alleghaniense* (C. Mull.) Grout. On wet shaded rock in ravines. Scattered.
Pylaisia selwynii Kindb. Collected once on tree in moist ravine.
Rhytidium rugosum (Hedw.) Kindb. In an extensive mat in a wet field. Destruction of the station by a new artificial lake is expected. Also collected on a wooded ridge near Moonville in Vinton County.
Sematophyllum carolinianum (C. Mull.) E. G. B. Common on moist shaded rocks in ravines.

LESKEACEAE

- Anomodon attenuatus* (Hedw.) Huben. Very common on moist shaded rocks and trees.
Anomodon minor (Beauv.) Lindb. Less common but in similar locations to the last.
Anomodon rostratus (Hedw.) Schimp. Very common on moist shaded rocks and trees.
Anomodon tristis (Cesati) Sull. On moist bark, usually on fallen logs in ravines. Scattered.
Leskea gracilescens Hedw. Common on stones and cement culverts.
Leskea obscura Hedw. Scattered, on fallen logs.
Leskea polycarpa Hedw. Growing on bases of willow trees periodically inundated by Hocking River.
Thelia asprella Sull. On tree bases and rotting wood. Common in the western part of Athens County and in Vinton County.
Thelia hirtella (Hedw.) Sull. Found in similar locations to the last but less common.
Thuidium delicatulum (Hedw.) Mitt. Very common on soil in open fields or wooded areas, tree bases, rotten wood or rock.
Thuidium microphyllum (Hedw.) Best. Specimen with many characters approaching those of *T. virginianum*. Collected once on rotting wood in moist ravine.
Thuidium pygmaeum Bry. Eur. Collected on moist shaded rocks in ravines.
Thuidium recognitum (Hedw.) Lindb. Collected once in a moist ravine. Also collected in Morgan County.
Thuidium virginianum (Brid.) Lindb. Collected on soil of dry wooded slopes.

HOOKERIACEAE

- Hookeria acutifolia* Hook. In moist cracks and pockets under sandstone overhangs. Not common.

LEUCODONTACEAE

- Leptodon trichomitrium* (Hedw.) Mohr. On trees in moist ravines. Not common and mostly in the western part of Athens County.
Leucodon sciuroides (Hedw.) Schwaegr. On trees in moist ravines. Scattered.

FABRONIACEAE

- Schwetschkeopsis denticulata* (Sull.) Broth. On trees in moist ravines. Not common.

FONTINALACEAE

- Fontinalis disticha* Hook. & Wils. Collected once in remnant of old Hocking Canal.
Fontinalis novae-angliae Sull. Collected once in western Athens County on rocks in stream above small falls. Common in areas of eastern and central Vinton County.

Additional species not reported from Athens County but collected recently in neighboring Vinton County include:

Sphagnum recurvum Beauv. Collected in a marshy valley between Moonville and the Athens County line.

Sphagnum subsecundum Nees. Found in extensive mats in bottomland near Zaleski.

Dicranum fuscescens Turn. Found in moist shaded ravine in Vinton Furnace Experimental Forest in the central part of Vinton County.

Grimmia laevigata (Brid.) Brid. Growing on high exposed ledge near Moonville.

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And What of Tomorrow. George O. Robinson. Comet Press Books, New York. 1956. 178 pp. \$3.00.

A popular nontechnical account of the development of nuclear energy, from the letter Einstein wrote to President Roosevelt in August, 1939, urging study of the possibilities of fission of uranium through the successful detonation of the thermonuclear bomb, to a glimpse of nuclear energy in the future. Sidelights are given which do not appear in conventional accounts. These add a great deal of human interest to this story.

The author is an ex-newspaperman who has been associated with the nuclear energy program since its early days and has personally witnessed many of the events he recounts. Often the author catches the spirit of men developing nuclear energy and gives many intimate pictures of them. However, in other spots, the recital of statistics goes on until one feels that the purpose is to stagger the reader.

There are some obvious errors. Twice, J. J. Thomson is credited with determining the nature of electrons in 1879. The commonly accepted date is 1897. Again, (on Page 75) reference is made to 400,000 tons of steel, "equivalent to the displacement of a battleship." Quite a battleship! However, since this is a nontechnical book, such errors probably are of small importance.

EDWARD S. FOSTER, JR.

OBSERVATIONS ON THE BIOLOGY AND MORPHOLOGY OF *OPHYRA AENESCENS*

(DIPTERA: MUSCIDAE)

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Ophyra aenescens was described by C. R. W. Wiedemann (1830) from specimens he collected in New Orleans, Louisiana. Wiedemann placed this species in the genus *Anthomyia* but Stein in 1897 transferred it to *Ophyra* Robineau-Desvoidy 1830.

Aldrich (1905), and others, have placed *Ophyra* in the family Anthomyiidae. After studying terminalia Crampton (1944) stated that *Ophyra* is a typical muscid and not an anthomyid. Our observations on the larval characters of *O. aenescens* indicate it is a typical muscid and we believe this species belongs in the family Muscidae and subfamily Phaoniinae. Two names, *Ophyra argentina* Bigot and *O. carbonaria* Shannon and DelPonte, are considered synonyms of *O. aenescens*.

This species was not studied by us for any known economic importance, but because it seemed unusual to find large numbers of both larvae and adults at a small municipal dump during the winter months when air temperatures were often below freezing.

Method of rearing flies in the laboratory.—The following method was developed for rearing flies in the laboratory. Adults were kept in a cage 10 inches wide, 12 inches high, and 13 inches deep. The floor and one end were of wood and the other end was fitted with a muslin sleeve. The sides and top were screen. Water and food were provided by a wad of wet cellulocotton sprinkled with cane sugar. Few eggs were laid and none of them hatched until the flies fed on animal flesh, and fish meal was satisfactory for this purpose.

Stender dishes of moist fish meal were used for oviposition. Moistness is necessary to prevent desiccation of the eggs. The dish must be loosely filled so as to leave cracks and crevices on the surface of the meal in which the flies place their eggs.

Masses totaling 300 to 400 eggs, gathered with a spatula, were put just under the surface of the medium for larval development. This medium consisted of 320 grams of the standard Chemical Specialties Manufacturing Association preparation, 25 grams fish meal, 200 cc. diamalt, one cake yeast, and 20 grams of brewers' yeast. These ingredients were thoroughly mixed and cold water was added until the mixture became moist. This amount of material filled a 6 inch diameter and 9 inch high battery jar about half full. After the eggs were added the top was covered with cheesecloth and the jar was kept at 80° to 82°F in a room illuminated from 7 A.M. to 8 P.M. No additional water was added as is usually done when rearing houseflies. When larval activity ceased the jar was uncovered and placed in a cage where the adults emerged.

Observations on the life history in the laboratory.—The eggs adhere to each other when laid and form masses. Counts of several masses revealed an average of 74 eggs per mass. It is difficult to remove individual eggs from their neighbors and separated eggs are often injured because they rarely hatch. Several females may oviposit in the same place but individual egg masses are usually evident. As stated earlier, the eggs are usually placed in cracks but in soft material, such as damp fishmeal, the ovipositor is often used to make a small hollow place in which the eggs are laid.

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The freshly laid egg is ivory white in color, approximately one millimeter long, and the greatest diameter is at the middle from which it tapers to the ends (fig. 1). The anterior end is flattened and the posterior end rounded. The dorsal surface has two ribs, or ridges, that extend the length of the egg. At first the chorion is smooth but after 12 hours of embryonic development longitudinal striations appear over its surface.

At 82°F the incubation period was 12 to 16 hours. In hatching a slit appears on the dorsal surface at the flattened anterior end and it quickly extends posteriorly between the two ridges. The larva crawls out head first.

The effects of low temperatures on eggs were studied as follows. Five tests were made using two egg masses for each test. The eggs were placed in shell vials half-filled with distilled water and the experimental temperatures were maintained for 48 hours after which the vials were placed at room temperature. None of the eggs in water which froze hatched. The lowest temperature at which exposed eggs hatched when returned to room temperature was 1°C. When kept at 8°C for 48 hours followed by room temperature, almost every egg hatched. A few experiments were run at high temperatures and the eggs hatched when maintained as high as 108°F but all larvae died within a few hours suggesting that they cannot develop at this temperature.

There are three larval instars which are similar in general shape, have 12 easily recognized segments, and superficially resemble the common housefly. Spination is limited to the locomotor pads. The newly hatched larva is about 1.5 mm. in length and the third instar may be as long as 13 mm. Each instar is characterized by distinctive features.

The first instar larva. The first segment has two pairs of papilla-like structures on the dorso-lateral surfaces which, in this stage only, look alike. The mouth hooks (fig. 2) are lightly pigmented. The anterior spiracles located laterally on the second segment, can be seen only with difficulty. The transparent integument permits observation of the tracheal system.

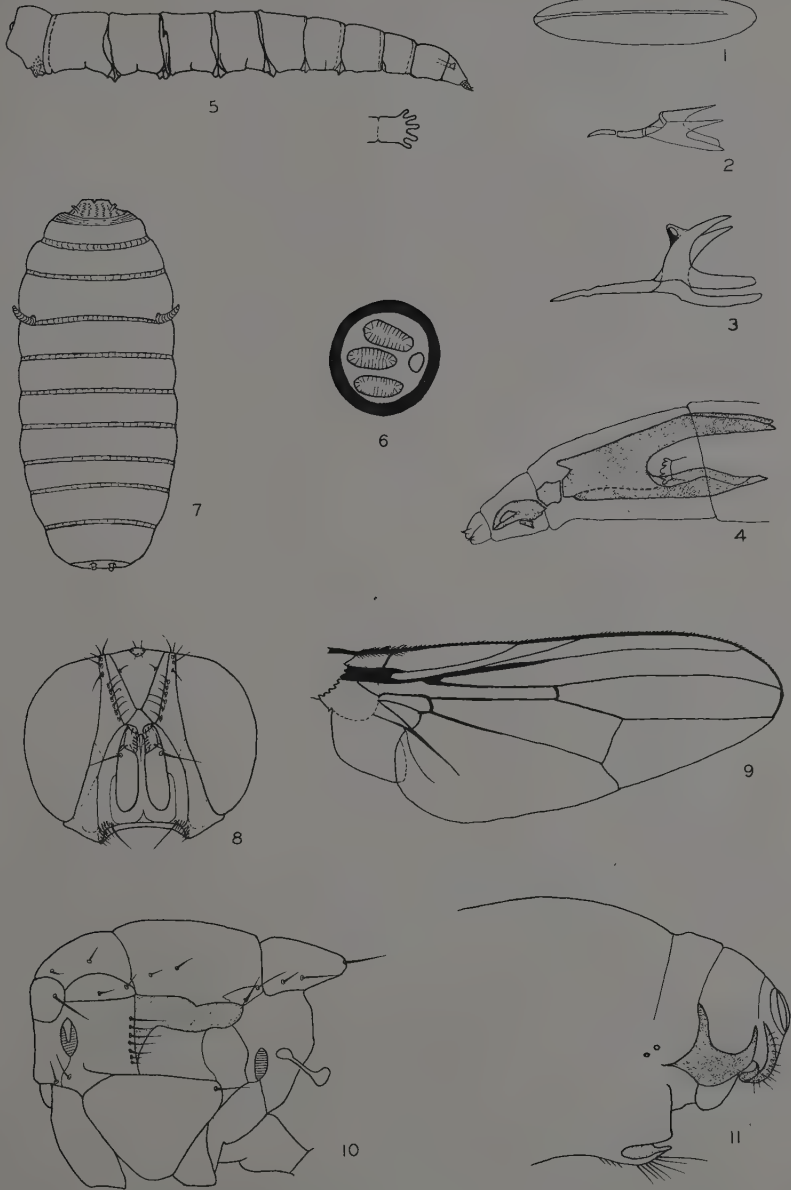
The second instar larva. The two pairs of papilla-like structures on the first segment are now different with the more dorsal pair being longer and annulated. The anterior spiracles are clearly visible with the stalk of each spiracle having five or six hemispherical knobs on the anterior margin. The heavily pigmented cephalopharyngeal skeleton (fig. 3), visible through the integument, extends posteriorly into the third segment.

The third instar larva (fig. 5). Again the papillae on the first segment are different with the ventral ones barely visible and the dorsal ones quite antenna-like. West (1951) calls corresponding structures on the housefly sensory lobes. The anterior margin of the first segment in dorsal aspect appears bilobed, and these oral lobes in ventral view superficially resemble the adult oral disc.

The cephalopharyngeal skeleton consists of eight sclerites (fig. 4). The mandibular sclerites are anteriormost and form the two mouth hooks which may be

EXPLANATION OF PLATE FIGURES

- FIGURE 1. Egg.
- FIGURE 2. Cephalopharyngeal skeleton, first instar larva.
- FIGURE 3. Cephalopharyngeal skeleton, second instar larva.
- FIGURE 4. Cephalopharyngeal skeleton, third instar larva.
- FIGURE 5. Third instar larva.
- FIGURE 6. Caudal spiracle, third instar larva.
- FIGURE 7. Puparium, four days old, containing a pupa.
- FIGURE 8. Head of female.
- FIGURE 9. Wing.
- FIGURE 10. Thorax, lateral view.
- FIGURE 11. Male external genitalia, lateral view.



extended from the oral cavity when used in locomotion and feeding. The bases of the mandibular sclerites articulate with the hypostomal sclerite. Each mandibular sclerite at its posterior-ventral margin has a dentate sclerite. The posterior margin of the hypostomal sclerite articulates with the fused portion of the two large pharyngeal sclerites which are the most conspicuous parts of the cephalopharyngeal skeleton. Each pharyngeal sclerite has a dorsal wing and a ventral wing. The two ventral wings are joined and form a support for the pharynx; the two dorsal wings are bridged anteriorly by the dorsopharyngeal sclerite.

From anterior to posterior there is a gradual increase in the diameter of the segments except for the last one which is conspicuously elevated over the one in front of it. The locomotor pads are on the fourth through the twelfth segments, although poorly developed on the eleventh, and they are covered with minute recurved spines. The locomotor pad on the twelfth segment is the largest and separated into two lobes with the anus between them. The caudal spiracles (fig. 6) appear as a pair of raised, heavily pigmented, circular discs near the center of the posterior surface of the terminal segment. Some of the internal organs can be seen through the body wall but fat accumulates and obscures these structures and gives the larva a creamy white color.

Pupation takes place in the skin of the third larval instar; hence, the covering of the pupa is a puparium and the pupa is of the coarctate type. The puparium (fig. 7) of twelve recognizable segments is a deep reddish brown within six hours after the onset of pupation. The first segment is reduced in size, roughened in texture, and retains the old larval anterior spiracles represented by a pair of light yellow minute projections. The ventral surface bears persistent locomotor pads on the last segment. Two days later the pupal spiracles, called spiracular horns, appear on the latero-dorsal surfaces between the fifth and sixth segments. These spiracular horns appear to be the pupa's only source of air since dissection reveals the larval spiracles are not connected with the pupa after the horns are fully developed. The minimum duration of the pupal stage was four days.

The distinguishing characters of the adults of this species are indicated in figures 8, 9, 10, 11, and in the key for separation of the three species of the genus found in north America.

The sexes can be easily separated by the contiguous eyes of the male and the separated eyes of the female and by the wing position at rest. The female holds her wings parallel to each other and the male's wings are crossed half way between the fifth and sixth veins. The male is 6 mm. in length and the female is usually no more than 0.5 mm. longer.

In the laboratory, males lived an average of 15 days and females lived an average of five days longer. Mating was not observed until the second day after emergence and eggs were produced two days later. To get some idea of reproductive capacity, pairs of newly emerged flies were placed in cages and the total number of adult flies obtained from each of six such pairs is indicated in table 1.

A generation took place in as little as 14 days in the laboratory at $80^{\circ}\text{F} \pm 2^{\circ}$. At temperatures above and below this range development was retarded. For eggs the minimum period to hatching was 12 hours, the larval stages had a minimum of five days to pupation, and the minimum pupal time was four days before the adults emerged. The preoviposition period was four days. The maximum life observed for males was 18 days and 35 days for females.

Additional field observations.—As mentioned earlier all stages of *Ophyra aenesceus* were found throughout the year and winter temperatures at ground level and above were often below freezing. No evidence was obtained that any stage went into a dormant period under unfavorable conditions. None of the life history stages was found to withstand freezing temperatures.

Three series of temperatures were taken in the field, about two inches under the surface of fermenting garbage where living larvae were present, when air temperatures five feet above the ground were 12°, 28° and 32°F. The data for the first temperature are apparently lost but for the second temperature five readings were from 96° to 106°F and for the third temperature eight readings were from 100° to 110°F. The larvae crawl around a lot and concentrations of them are found where the temperature is from 80° to 90°F and they pupate in areas of similar temperature.

Survival of adults during winter appears possible due to several characteristics of behavior. The adults are seldom found far from the fermenting garbage on which they feed and on which the eggs are laid. At night the adults stay on their food, walking over it and feeding and crawling under its surface, which is in distinct contrast to other species studied which were observed to leave their food and spend the night on vegetation or buildings nearby. Thus, the adults are able to avoid the cold of winter and also unfavorable periods of intense heat during summer.

TABLE 1

The offspring reaching adulthood and their sex of six individually caged pairs of parents

Cage Number	1	2	3	4	5	6
Male offspring	145	163	148	158	158	234
Female offspring	180	176	128	192	167	204
Total offspring for each pair	325	339	276	350	325	438

This species is able to fly considerable distances and Bishopp (1921), studying dispersal of flies by flight, took four specimens 4.4 miles from the point of liberation.

Since 1930 when *Ophyra aenescens* was described from specimens collected in New Orleans the species has been reported from a number of southern states, islands of the Caribbean Sea, and various places in Mexico, Central and South America. In the northern states Leonard (1926) reported this species for New York; specimens in The Ohio State University Entomology Museum were collected in Southern California, and we have taken specimens in Ohio, Kentucky, and West Virginia.

Two additional species of *Ophyra* are known to occur in the United States. These are *O. leucostoma* (Wied.), which is common and widely distributed, and *O. capensis* found at Troy, N.Y. and kindly reported to us by Dr. H. R. Dodge. These three species can be separated by the following key.

1. Palpi rufous-yellow; hind tibia with one long postero-dorsal bristle beyond middle, and two short antero-ventral bristles; calypters yellow; one humeral bristle. *aenescens*.
Palpi black. 2
2. Hind tibia conspicuously curved; two humeral bristles; calypters fuscous. *leucostoma*.
Calypters white. *capensis*.

SUMMARY

All stages of *Ophyra aenescens*, a typical muscid fly, were found in and around decomposing garbage at a small municipal dump in winter when air temperatures were often below freezing. This observation stimulated a study of the biology of this species both in the field and in the laboratory. These observations are

reported and the different stages in the life history are described and illustrated. The method used in culturing the flies in the laboratory is described.

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THE OXIDATION OF β -AROYL PROPIONIC ACIDS BY SODIUM HYPOCHLORITE¹

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As part of a general study of the applicability of the Friedel and Crafts Reaction to qualitative organic chemistry, the oxidation of β -aroyl propionic acids has been investigated. The β -aroyl propionic acids have been recommended as derivatives of aryl hydrocarbons by Reinheimer and Taylor (1954). If these acids could be oxidized to the corresponding benzoic acid, a second derivative of the original hydrocarbon would become available.

MATERIALS AND METHODS

Procedures for the oxidation of a keto containing side chain without simultaneously oxidizing other side chains generally require the use of hypochlorite. Several procedures were recommended in the literature. Zaki and Fakim (1942) used an alkaline NaOBr solution. This procedure was not regarded as suitable, for the reagent was expensive and had to be prepared immediately before use. Fieser and Bradsher (1936) used NaOCl in an acid solution. They noted that chlorination of the benzene ring occurred if the ring were sufficiently activated. While the aromatic rings in this series of aroyl propionic acids were not highly activated, this chlorination reaction might possibly interfere. Short, Stromberg and Wiles (1936) were able to avoid ring chlorination by the use of alkaline hypochlorite solution. An adaptation of their procedure was employed.

The details of the modified procedure of Short, Stromberg and Wiles are as follows: An oxidizing solution was prepared by dissolving 2 gm. of NaOH in 40 ml. of 5.25 percent NaOCl and diluting to 100 ml. with water. One gm. of the β -aroyl propionic acid was dissolved in 100 ml. of the NaOCl solution and was warmed in a water bath for 20 to 30 minutes. After the reaction mixture had been refluxed for an additional one-half hour, the hot solution was filtered and cooled to room temperature. The acid product was precipitated by bubbling in sulfur dioxide for 4 to 5 minutes. The crude derivative was separated by filtration, washed several times with cold water and finally recrystallized from ethanol or an ethanol water mixture.

¹Presented at the Sixty-Fourth Annual Meeting of the Ohio Academy of Science, Delaware, Ohio, April, 1955.

²Taken from a portion of the Independent Study Thesis, submitted by Ellis List to the College of Wooster, in 1955.

The yields which are reported in table 1 were taken on material that was dried for 24 hours in a vacuum dessicator; all melting points reported were taken with a calibrated thermometer.

DISCUSSION AND RESULTS

The results of this oxidation procedure are collected in table 1 and table 2. In table 1 β -keto acids and their oxidation products are listed according to the boiling point of the parent hydrocarbon from which they were derived. The oxidation products provide satisfactory derivatives of the original hydrocarbon

TABLE 1
Oxidation products of aroyl propionic acids of aromatic hydrocarbons

Aromatic Hydrocarbons	B.P. °C	M.P. of Aroyl Propionic Acid, °C	Crude Yield %	M.P. °C Derivative	
				Observed	Literature
Benzene	80	116.5-17.5	64.8	121.7(1x)	121.7 (Beilstein, 1926)
Toluene	111	127.0-28.5	69.7	180.5-81(2x)	180 (Beilstein, 1926)
Ethyl Benzene	135	107.0-08.5	57.6	111-12(1x)	110-11 (Beilstein, 1926)
m-Xylene	139	112.0-13.0	74.0	125.1-26.6(2x)	126 (Beilstein, 1926)
o-Xylene	142	130.0-31.0	91.3	165.9-65.9(1x)	166 (Beilstein, 1926)
Cumene	153	139.5-41.5	73.8	116.6-18.0(1x)	116-18 (Beilstein, 1926)
n-Propylbenzene	158	120.5-22.5	59.3	141.4-41.9(1x)	140-41 (Beilstein, 1926)
Mesitylene	164	109-09.5	60.4	148-50(1x)	147-49 (Beilstein, 1926)
tert-Butylbenzene	169	123.5-25	82.2	164.1-65.2(3x)	164 (Beilstein, 1926)
sec-Butylbenzene	173	95.5-96.5	54	92.5-93.5(1x)	91-92 (Marvel, 1943)
n-Butylbenzene	182	111-12.5	82.6	101-102(1x)	102.5-03 (Beilstein, 1926)
Tetralin	206	121-22	60.1	152.2-53.0(3x)	154 (Heilbrun, 1953)
Phenylcyclohexane	237	136-36.5	96.9	191.5-93.5(3x)	198 (Bordroux, 1938)
β -Methylnaphthalene	32*	165-66	77	228.5-30.5(2x)	228-30 (Heilbrun, 1953)
Diphenyl	70*	183.5-85	66.6	223.5-24.5(1x)	224 (Beilstein, 1926)
Naphthalene	80*	172-73	82.9	182-83(1x)	182-82.5 (Beilstein, 1926)
Acenaphthene	95*	209-210	78.1	217-17.5(1x)	217 (Beilstein, 1926)
Fluorene	115*	212-13	52.2	Sublimes	Sublimes (Beilstein, 1926)

*Melting point.

(x) represents the number of recrystallizations.

TABLE 2
Oxidation products of aroyl propionic acids

Original Aromatic Hydrocarbon Used	M.P. °C of Keto Acid	M.P. °C of Oxidation Product
sec-Butylbenzene	95.5-96.5	92.5-93.5
Ethyl benzene	107.5-08.5	111-12
Mesitylene	109-09.5	148-50
n-Butylbenzene	111-13.5	101-02
m-Xylene	112-13	125.1-26.6
Benzene	116.5-17.5	121.7
n-Propylbenzene	120.5-22.5	141.4-41.9
Tetralin	121-22	152.2-53
tert-Butylbenzene	123.5-25	164.1-65.2
Toluene	127.5-28.5	180.5-81
o-Xylene	130-31	165.4-65.9
Phenylcyclohexane	136-36.5	191.5-93.5
Cumene	139.5-41.5	116.6-18
β -Methylnaphthalene	165-66	228.5-30.5
Naphthalene	172-73	182-83
Diphenyl	187.5-88	223.5-24.5
Acenaphthene	209-10	217-17.5
Fluorene	212-13	Sublimes over 260

for: a) the procedure is simple and the yields are fair to good; b) the products are generally pure, so that only one or two recrystallizations are required to obtain a sharp melting point; c) the melting points are high, and the melting point difference between successive members of the series is sufficient for positive identification; d) the melting point of the product is considerably different from that of the reactant in all but two cases.

The data obtained from the oxidation of this series of keto acids may be arranged to show that the keto acids may also be identified by means of the melting points of the oxidation products. This arrangement is presented in table 2, in which the keto acids are listed according to melting point. The oxidation products are suitable as derivatives of the keto acids for essentially the same reasons as presented above.

SUMMARY

The oxidation of β -aroyl propionic acids was successful in 17 of 18 trials. The substituted benzoic acids obtained are recommended as suitable derivatives for both the original hydrocarbon and the β -aroyl propionic acids.

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A Manual of Parasitic Mites. E. W. Baker, T. M. Evans, D. J. Gould, W. B. Hull, and H. L. Keegan. National Pest Control Association, Inc., 30 Church St., New York 7. 1956. 170 pp. \$4.25.

The parasitic mites, exclusive of ticks, are covered in this splendid book. Also included are species which are not parasitic on man or domestic animals but which occasionally occur on these hosts or in their habitations, thus causing annoyance.

The public is becoming aware of mites. In contrast with twenty years ago when mites were rarely brought in for identification, now mites are frequently recognized as the source of trouble or suspected of causing trouble and they are often brought in for identification and for recommendations on control. Help is usually sought in laboratories dealing with the zoological, medical, and veterinary sciences and workers in these places will find this excellent volume very useful. Students of parasitology and especially medical entomology will find this reference book necessary.

For each species of mite considered the authors include illustrations, a description, life history and control data when available, and pertinent references. There is a key for identification of the species (but this reviewer will depend mainly on the illustrations) and an index.

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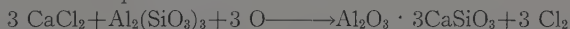
A STUDY OF THE REACTION BETWEEN OXYGEN AND MIXTURES OF KAOLINITE AND CERTAIN METAL CHLORIDES AT ELEVATED TEMPERATURES

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INTRODUCTION

The reaction between oxygen and mixtures of metal halides and kaolinite has been known for some time (Solvay, 1880, 1885, 1890; Kitaigorodskii *et al.*, 1935). Solvay found that when mixtures of calcium chloride and "siliceous clay-like substances" were reacted with air in a heated furnace, chlorine gas was produced. The reaction was pictured as follows:



Mixtures of sodium chloride and siliceous substances have been subjected to heat and electrolysis in the presence of oxygen. Such reactions have been reported to form alkali metal silicates and chlorine gas (Van Denburgh, 1901). Alkali aluminates together with hydrogen chloride and free chlorine have been produced by heating mixtures of alumina minerals, sodium chloride and carbon (or sulfur) in air containing sulfur dioxide and water vapor (Peniakoff, 1909). Since most of these reactions were carried out with the aim of producing hydrogen chloride, or chlorine, or both, very little work was done in establishing the identity of the solid silicate products. The author has examined some of these reactions with the purpose of determining the nature of the solid products.

MATERIALS AND PROCEDURES

A high grade Alabama kaolinite was used in all of the experiments described herein. An analysis of the kaolinite yielded 46.69 percent silicon dioxide (calculated for $\text{Al}_2\text{O}_3 \cdot 2\text{SiO}_2 \cdot 2\text{H}_2\text{O}$, 46.56%), 39.67 percent aluminum oxide (calculated value, 39.49%), and 12.60 percent water (calculated value, 13.93%). The kaolinite was ground to a fine powder in an agate mortar and that portion passing through a number 200 sieve was heated to a constant weight in a large platinum dish at a temperature of approximately 650°C. Heating separate samples of the kaolinite to a temperature of 900°C produced no further loss in weight; so, it was assumed that dehydration was complete at the lower temperature. It has been reported that the dehydration of kaolinite is practically complete at temperatures between 500 and 600°C (Eitel, 1954). The dehydrated material was stored in a stoppered bottle over anhydrous calcium sulfate in a desiccator. The nature and structure of the dehydrated kaolinite will be discussed at a later point in this paper.

Reagent grade sodium chloride, made by Baker and Adamson, was heated to a constant weight at 200°C. The salt was allowed to cool in a desiccator, then ground to a fine powder in an agate mortar. The salt was stored in the desiccator with the dehydrated kaolinite.

Reagent grade, anhydrous, calcium chloride, made by Baker and Adamson, was ground to a fine powder in an agate mortar and stored in a tightly stoppered bottle in a desiccator. Both the sodium chloride and calcium chloride were pulverized in a dry box to minimize hydration by exposure to the atmosphere.

The various mixtures of kaolinite, sodium chloride, and calcium chloride that were used in this investigation were prepared by placing the components (in the

¹This study has been supported by University of Toledo Research Foundation, University of Toledo, Toledo 6, Ohio.

desired mole ratio) in tightly stoppered bottles and rolling and shaking each bottle for a period of 20 minutes to produce a homogeneous mixture. Precautions were taken during the weighing of the individual components to avoid hydration, and after the mixing operation, the bottles were placed in a desiccator.

All of the reactions between oxygen and the solid mixtures were carried out in a system consisting of 1. source of oxygen, 2. gas flow meter, 3. mercury safety valve, 4. ascarite tower, 5. alundum tube, extending through an electric tube furnace, 6. safety flask, and 7. chlorine absorption tower. "Tygon" tubing was used to connect all parts of the system. The alundum tube extended a sufficient distance beyond the furnace to prevent excessive heating of the "Tygon" tubing connections at each end. The oxygen used in the experiments was of U.S.P. grade. The chlorine absorption tower contained aqueous sodium hydroxide.

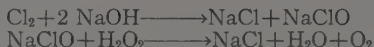
Generally speaking, the same procedure was followed in carrying out all of the reactions described herein.

1—A measured volume of sodium hydroxide solution was transferred to the absorption tower. A second and like volume of the base was placed in a titrating flask and used later as a blank.

2—A weighed sample of the solid mixture to be reacted was placed in an alundum boat, and the boat was pushed into the alundum tube to a point near the center of the furnace. Large alundum boats were used (13 x 2 x 1 cm.) and the solid was spread evenly over the bottom of the boat to afford a maximum surface area for reaction. The end of the boat facing the oncoming oxygen was cut down to allow a more even flow of the gas over the sample.

3—The system was closed; the rate of oxygen flow was adjusted; and the furnace was turned on with the rheostat at the proper setting. At the end of each trial run, the absorption tower was removed from the system and the flow of oxygen was stopped. After the sample and furnace had cooled to room temperature, the boat was removed and its solid contents were placed in a stoppered bottle for examination at a later time. Both ends of the furnace tube were plugged with ascarite tubes during the cooling period.

4—The sodium hydroxide solution in the absorption tower was treated with 15 ml. of 30 percent hydrogen peroxide and titrated with standard hydrochloric acid to a methyl orange-xylene cyanol end point. The sodium hydroxide blank was treated in a like manner.



The amount of chlorine liberated during the reaction and absorbed by the sodium hydroxide was calculated as follows:

$[(\text{Vol. HCl (blank) (ml.)} - \text{Vol. HCl (absorption tower) (ml.)}) \times N \text{ (normality of HCl)}] \times 0.0355 = \text{weight of chlorine (grams)}$

The electric tube furnace was calibrated with an iron-constantan thermocouple and the temperature of the furnace was plotted against time for various rheostat settings. It was noted that a period of about one hour was required before the furnace reached a maximum temperature at each rheostat setting. In all of the trial runs made, the warm up period of one hour was not considered in the total time that the sample was to be in the furnace at the given final temperature.

Certain of the reaction products were examined by x-ray diffraction methods. A General Electric Model XRD3 x-ray apparatus, with Cu K alpha radiation (nickel filter) and a camera of 14.32 cm. diameter was used. The samples were sealed in pyrex capillary tubes to prevent hydration during the analysis. Differential thermal analysis was employed in some cases for comparing the final products of the reaction with the reactants. The method and apparatus has been described and used previously for identifying various mineral products (Kalousek *et al.*, 1949).

RESULTS

Reaction between Oxygen and Mixtures of Kaolinite and Sodium Chloride

Two mixtures of kaolinite and sodium chloride were reacted with oxygen at elevated temperatures. The composition of the solid mixture prior to its reaction, the experimental conditions, and the amount of chlorine gas evolved during the reaction have been summarized in table 1. When portions of the sodium chloride, used in the preparation of the mixtures, were placed in the reaction chamber (trial # 6, table 1), there was no change noted in the concentration of the sodium hydroxide in the absorption tower.

TABLE 1

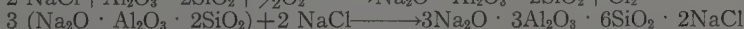
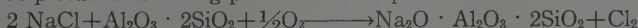
Reaction between oxygen and mixtures of kaolinite, sodium chloride, and calcium chloride at elevated temperatures

Trial	Composition of Solid Reactant ^a	Temp. °C	Time hr.	Per Cent of Total Chlorine in Reactant Liberated ^b
1.	Al ₂ O ₃ ·2SiO ₂ and NaCl in a 1:1 mole ratio, sample wt. = 1.000 g.	600	1	5.9
2.	Same as trial # 1	600	2	14.7
3.	Same as trial # 1	600	3	16.5
4.	Same as trial # 1	800	2	43.8
5.	Al ₂ O ₃ ·2SiO ₂ and NaCl in a 1:2 mole ratio, sample wt. = 1.000 g.	800	2	19.1
6.	NaCl, sample wt. = 1.000 g.	800	2	0.0
7.	Al ₂ O ₃ ·2SiO ₂ and CaCl ₂ in a 1:1 mole ratio, sample wt. = 2.500 g.	700	1½	7.3
8.	Same as trial # 7	800	2½	25.5
9.	Same as trial # 7	800	3	35.1
10.	Al ₂ O ₃ ·2SiO ₂ and CaCl ₂ in a 1:2 mole ratio, sample wt. = 2.500 g.	800	2½	85.0
11.	Al ₂ O ₃ ·2SiO ₂ and CaCl ₂ in a 2:1 mole ratio, sample wt. = 2.500 g.	800	3	34.8
12.	CaCl ₂ , sample wt. = 2.500 g.	800	2	0.0
13.	Al ₂ O ₃ ·2SiO ₂ , NaCl, and CaCl ₂ in a 1:1:2 mole ratio, sample wt. = 1.000 g.	800	2	35.0
14.	Al ₂ O ₃ ·2SiO ₂ , NaCl, and CaCl ₂ in a 1:2:4 mole ratio, sample wt. = 1.000 g.	800	2	37.5
15.	Same as trial # 14	800	3	47.0
16.	Same as trial # 14	800	3½	52.0
17.	Same as trial # 14	800	9	97.7
18.	Same as trial # 14, but the Al ₂ O ₃ ·2SiO ₂ was pre-ignited to 1000°C	800	3	36.0

^aThe rate of oxygen flow through the system was approximately 4 liters per hour in all of the trials.

^bOnly the best of several determinations has been reported in this table.

The solid product of trial # 4 (table 1) was examined by x-ray diffraction methods and the measured "d" values have been listed in table 2. A comparison of these values with those of the other substances listed in table 2 indicates that some unreacted kaolinite as well as sodium chloride is present. There is little or no agreement between the x-ray data of the product and those reported for the various sodium aluminates and sodium silicates thus far prepared and identified by other workers (A.S.T.M., 1945). Although the x-ray data are not conclusive, there is evidence that nephelite, Na₂O·Al₂O₃·2SiO₂, and sodalite, 3Na₂O·3Al₂O₃·6SiO₂·2NaCl, are present in the reaction product. The formation of these products might be pictured as taking place in two steps.



According to these proposed reactions, a mixture of sodium chloride and kaolinite, in a 1:1 mole ratio, would liberate 75 per cent of the total chlorine present as chloride ion during the chemical change. Since the measured percentage of chlorine evolved in the best of several trials made is considerably lower than this theoretical value, and since unreacted kaolinite and sodium chloride are present in the product, it can only be concluded that the proposed reactions are not complete under the chosen experimental conditions.

Reaction between Oxygen and Mixtures of Kaolinite and Calcium Chloride

Three different mixtures of kaolinite and calcium chloride were reacted with oxygen. The composition of the mixtures, the experimental conditions, and the amount of chlorine gas produced by the reactions have been summarized in table 1. A portion of the calcium chloride used in the preparation of the mixtures was treated with oxygen at 800°C (trial # 12, table 1).

The x-ray diffraction data obtained for the product of trial # 10 (table 1) have been included in table 2. The data of table 2 indicate that both unreacted calcium chloride and kaolinite are present in the reaction product. There is good agreement between the measured "d" values of the product and those reported for calcium aluminum silicate, $\text{CaO} \cdot \text{Al}_2\text{O}_3 \cdot 2\text{SiO}_2$. The x-ray data of the product show little or no agreement with those reported for various calcium aluminates and calcium silicates (A.S.T.M., 1945).

Reaction between Oxygen and Mixtures of Kaolinite, Sodium Chloride, and Calcium Chloride

Pertinent data concerning a few of the reactions carried out between oxygen and mixtures of kaolinite, sodium chloride, and calcium chloride have been summarized in table 1. A portion of the product of trial # 17 (table 1) was subjected to x-ray analysis. The x-ray data have been reported in table 2. Although calcium chloride and kaolinite appear to be absent in the product, there is evidence that some sodium chloride is still present. The measured "d" values of the product are in good agreement with those reported for calcium aluminum silicate, $3\text{CaO} \cdot \text{Al}_2\text{O}_3 \cdot 2\text{SiO}_2$. The fate of the reacted sodium chloride is unknown, although there is some indication that sodalite is present in the product. Some reacted calcium chloride has yet to be accounted for, since the compound identified is a 3:1 (CaO:kaolinite) combination while a 4:1 ratio was present in the original mixture. A survey of the x-ray data given in the literature (A.S.T.M., 1945) for various combinations of sodium oxide, calcium oxide, aluminum oxide, and silicon dioxide was made, but only the compound mentioned above seemed to agree with the x-ray data of the product.

Two of the reaction products (trials # 16 and # 17 in table 1) were examined by differential thermal analysis. The thermal analysis curves for these products along with those of the starting materials have been duplicated in figure 1. The curve for sodium chloride is fairly regular until its melting point is reached at 810°C. The curve for calcium chloride shows several endothermic peaks. Those peaks at 170 and at 200°C represent dehydration processes. The peak at 770°C corresponds with the melting point of the salt. In order to account for the dehydration peaks, it was assumed that the anhydrous material underwent some hydration during its preparation for thermal analysis and during the early stages of the analysis. The curve for the dehydrated kaolinite exhibits no endothermic or exothermic peaks over the temperature range of 20 to 800°C.

The thermal analysis curve of the product of trial # 16 has three pronounced endothermic peaks. The first, which occurs at 150°C, cannot be accounted for at this time. The minor peak at 190°C is probably due to the dehydration of unreacted calcium chloride in the product. The peak at 520°C seems to confirm this suspicion. The curve for the product of trial # 17 has only one pronounced

endothermic peak and that occurs at 150°C . This peak coincides with that of the other product. None of the calcium chloride peaks are evident in the curve; and its absence is in agreement with the x-ray data of table 2. The fact that the thermal analysis curves for both products show identical peaks at 150°C is a good indication that the same substance (or substances) is present.

Since the mixture of kaolinite, sodium chloride, and calcium chloride, in a 1:2:4 mole ratio, appeared to undergo considerable reaction with oxygen, attention was turned to the study of the kinetics of the reaction. Numerous experiments were carried out to determine the effect of the rate of flow of oxygen

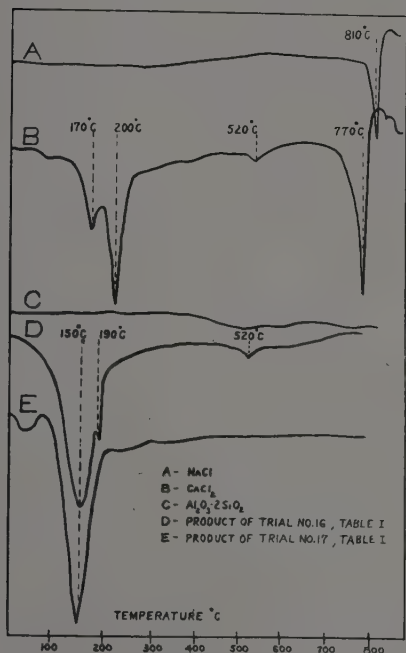


FIGURE 1

FIGURE 1. Differential Thermal Analysis Curves.

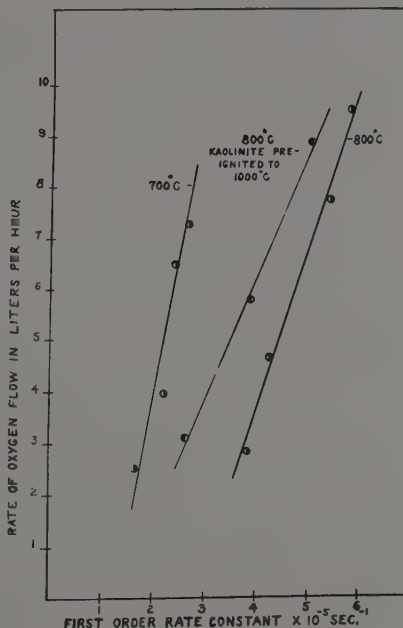


FIGURE 2

FIGURE 2. Relationship between reaction rate of oxygen with mixtures of kaolinite, calcium chloride and sodium chloride and the rate of oxygen flow through the reaction chamber.

through the reaction chamber on the extent and rate of the reaction. During each trial run the amount of chlorine liberated was determined at various time intervals. The results of a typical set of experiments have been summarized in table 3. The rate data in table 3 follow a first order pattern with respect to the chlorine present as chloride ion in the reaction mixture. The rate constants calculated from these and other data have been recorded in table 4.

Since the rate constants increase proportionally with an increase in rate of oxygen flow, it appears that the reaction is first order with respect to both the concentration of the halide ion and the amount of oxygen in the reaction chamber. The calculated rate constants have been plotted against rate of oxygen flow in

TABLE 2

X-ray diffraction data of reactants and products of the reaction between oxygen and mixtures of kaolinite, sodium chloride, and calcium chloride at elevated temperatures

Kaolinite (anhydrous)	Sodium Chloride		Calcium Chloride		Nephelite		Sodalite		CaO·Al ₂ O ₃ ·2SiO ₂		3CaO·Al ₂ O ₃ ·2SiO ₂		Reaction Products (table 1)								
	d	I/I ₀	d	I/I ₀	d	I/I ₀	d	I/I ₀	d	I/I ₀	d	I/I ₀	d	I/I ₀	d	I/I ₀	d	I/I ₀			
			4.46	60			4.21	80			4.61	40			4.23	S	4.44	M	4.24	W	
3.70	M						3.83	80			4.04	60			3.81	M	4.03	M	3.81	VW	
											3.70	40			3.70	S	3.71	M	3.67	W	
3.51	MW										3.57	60			3.49	S			3.41	VW	
3.34	VS	3.25	50	3.43	20	3.27	70	3.23	40			100			3.35	VS	3.33	S	3.26	W	
											3.19	100			3.25	M					
2.92	M			3.03	100	3.01	100			2.96	60	2.98	100	3.00	M	3.01	M	2.95	M	2.98	S
		2.81	100	2.84	60	2.87	70	2.91	40							2.83	M	2.90	M	2.88	VW
2.64	M							2.85	60							2.75	M	2.83	M	2.81	VS
								2.79	60									2.62	M	2.66	S
								2.69	40							2.60	M				
								2.60	90							2.52	VW	2.48	M	2.54	W
								2.50	40												
								2.41	60							2.44	M			2.43	M
																				2.34	W
				2.32	80	2.34	80	2.25	70							2.27	W				
2.23	MW			2.23	60	2.29	70	2.25	70							2.22	W	2.21	M	2.11	W
2.11	MW							2.13	80							2.11	W	2.10	W		
		1.99	90	2.07	60	2.08	60			2.13	50	2.14	60	1.97	W			2.05	M	1.98	VS
										2.08	40									1.94	VW
								1.93	60											1.91	W
1.88	MW			1.90	80	1.93	60	1.93	70			1.92	60	1.88	W	1.90	S	1.90	S	1.91	W
				1.85	60			1.83	40											1.84	M

figure 2. Of course, there is always some question as to the validity of the rate constant calculated for a heterogeneous system, and one can only say that a reaction in such a system appears to be of a certain order.

Mixtures of the same ratio but containing kaolinite which had been pre-ignited to 1000°C were found to react somewhat slower with oxygen than those mixtures containing kaolinite which had been dehydrated at 650°C. Reactions between

TABLE 3

The effect of the rate of oxygen flow on the rate of the reaction between oxygen and mixtures of kaolinite, sodium chloride and calcium chloride (1:2:4 mole ratio) at 800°C

Time (minutes) ^a	Amount of Chlorine Gas Evolved ^b		
	Oxygen Flow 2.86 liter/hr.	Oxygen Flow 4.68 liter/hr.	Oxygen Flow 7.80 liter/hr.
60	0.0470 g.	0.0488 g.	0.0679 g.
90	0.0818	0.0958	0.1044
120	0.1088	0.1219	0.1375
150	0.1314	0.1463	0.1652
180		0.1689	
195			0.2052
210	0.1680		
240		0.2124	0.2400
275	0.2046		

^aTime zero was taken when the sample was placed in the furnace at room temperature and the flow of oxygen was started.

^bThe total amount of chlorine in each sample (as chloride) = 0.4500 g.

TABLE 4

First order rate constants for the reaction between oxygen and mixtures of kaolinite, sodium chloride, and calcium chloride

Solid Reactants	Temp. °C	Rate of Oxygen Flow (Liter/hr.)	First Order Rate Constant (Sec. ⁻¹)
Al ₂ O ₃ ·2SiO ₂ , NaCl, and CaCl ₂ in a 1:2:4 mole ratio	700	2.53	1.7 ± 0.2 × 10 ⁻⁵
	700	3.98	2.2 ± 0.1 × 10 ⁻⁵
	700	6.50	2.4 ± 0.1 × 10 ⁻⁵
	700	7.20	2.7 ± 0.3 × 10 ⁻⁵
	800	2.86	3.8 ± 0.3 × 10 ⁻⁵
	800	4.68	4.3 ± 0.1 × 10 ⁻⁵
	800	7.80	5.5 ± 0.1 × 10 ⁻⁵
	800	9.60	5.9 ± 0.2 × 10 ⁻⁵
Same mixture as that described above, but the kaolinite was pre ignited to 1000°C	800	3.10	2.7 ± 0.2 × 10 ⁻⁵
	800	5.80	3.9 ± 0.2 × 10 ⁻⁵
	800	8.92	5.1 ± 0.1 × 10 ⁻⁵

oxygen and mixtures of the same composition but containing hydrated kaolinite were also examined. The rate constants calculated for these reactions (at 800°C and with various rates of oxygen flow) were not as consistent as those obtained with the pre-ignited kaolinite. The reaction was observed to be very slow in its initial stages, but as it proceeded, its rate gradually approached that measured for the anhydrous kaolinite. The slow initial rate can be attributed to competi-

tion between oxygen trying to approach the solid mixture and the water vapor being driven out of the solid. As dehydration subsides, it is reasonable to assume that the rate of reaction would approach that previously noted for anhydrous kaolinite.

DISCUSSION OF RESULTS

The dehydration of kaolinite has been the topic of numerous investigations (Eitel, 1954). It has been observed that the dehydration sets in at about 450°C and that meta-kaolinite is formed at temperatures within the range of 480 to 650°C. The crystal structure and the particle size of the kaolinite play an important part in determining the temperature at which this process begins and ends. Meta-kaolinite has also been the subject of considerable study. It has been reported to be homogeneous, like the individual crystal of kaolinite, and is often considered to be an unstable semi-crystalline complex. The readiness with which it reacts with acids and bases, in direct contrast to the behavior of hydrated kaolinite, seems to agree with this concept. When meta-kaolinite is heated above 900°C, it disintegrates to form a mixture of silica and alumina, and at temperatures above 1000°C fine mullite needles, $3\text{Al}_2\text{O}_3 \cdot 2\text{SiO}_2$, have been observed (Eitel, 1954).

The difference between the reactivity of the mixtures containing kaolinite which had been pre-ignited to 1000°C and those in which the kaolinite had been pre-ignited to 650°C (table 1 and 4) can be accounted for on the basis of the structure of the pre-ignited kaolinite, itself. The former is either a mixture of oxides or an aluminum silicate (in the case of mullite) which is resistant to chemical attack, while the latter is a "loose" crystalline structure, quite susceptible to the chemical action of alkaline oxides.

Both sodium chloride and calcium chloride failed to react with oxygen in the absence of kaolinite (table 1). This would seem to indicate that the kaolinite not only acts as an acceptor for the oxides of sodium and calcium, once they have been formed, but that it also serves as a catalyst in the replacement of the chloride ion with the oxide ion in the sodium and calcium chlorides.

The production of nephelite (or nepheline) by the reaction of oxygen with mixtures of kaolinite and sodium chloride does not represent a new synthesis. Nephelite has been recently synthesized by heating mixtures of sodium carbonate, aluminum oxide, and silicon dioxide to 1200°C (Miyashiro *et al.*, 1954).

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NOTES ON THE CURCULIONOIDEA

14. A contribution to the knowledge of the Curculionoidea.

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During the last several years a number of species of the Curculionoidea have come to the author's attention which are of particular interest in that they represent new records for, or new distribution records in the United States. Some were collected by the author and his wife; others were in material sent for determination. Other data are included here regarding the taxonomic status or the proper name of some species.

Anthribidae

A single example of *Piesocorynus moestus* (LeConte) was beaten from a dead branch of an oak in Scioto Co., VI-25-55, ELS, (ELS). Previously this species was recorded and known only from the states east of the Appalachian Mountains and the Gulf States. Its occurrence in Ohio increases vastly the distribution of this species.

Brachyderinae

Two examples of *Lachnopus argus* (Reiche) (1840, p. 275), a native of Cuba, were found crawling on a sandy strip of beach on Sugar Loaf Key, V-1-53, NJ & ELS. There is also a single abraded example in the National Museum labeled only "Fla."

The fact that the two examples collected on Sugar Loaf Key were taken alive would seem to indicate that this species is probably established in this country at least in a local area. *L. argus* may be distinguished from our other species, *L. floridanus* Horn by the following key:

1. Smaller, less than 10.0 mm. in length; dorn of dorsum uniform reddish brown to reddish black; prothorax coarsely, irregularly punctured; elytra clothed with narrow elongate appressed scales and with numerous more or less circular spots of pearly, elliptical scales.....*floridanus* Horn
- 1'. Larger, 12.0 mm. or more in length; body black with prothorax finely, densely punctured; elytra with vestiture restricted to circular spots of overlapping pearly, elliptical scales.....*argus* (Reiche)

On *L. argus* the pearly scales of rostrum and ventral side frequently with a bluish tinge.

L. floridanus Horn was very abundant on Cape Sable, Fla., V-28-53, NJ & ELS, on *Solanum torvum*. More than 200 examples were found in one small area on the aforesaid host.

Brachyrhininae

The neoholotype of *Peritelus* (*Cercopesus*) *chrysorrhoeus* Say, designated in Sleeper (1955, p. 288), has been removed from (ELS) to the entomological collection at The Ohio State University in compliance with recent changes in the Rules of Zoological Nomenclature, Copenhagen Decisions on Zoological Nomenclature, Article 31, p. 29, par. 35(4).

Three examples of *Cercopesus chisaius* Sleeper, described from Illinois and recorded from Iowa, Missouri, and Arkansas, were collected on Cream Ridge, near Crane Hollow, Hocking Co., Ohio, VI 26 56, ELS, (ELS). The Hocking Co. examples exhibit no apparent variation from the type series which, in as much as the species is apterous, would seem to indicate that the distribution is probably nearly continuous between the previously published areas and Hocking Co., Ohio. The Ohio examples were found in grass beneath a choke-cherry tree.

Tychiinae

The name *Tychius tomentosus* (Herbst) (1797, p. 278) must replace that of *Tychius stephensi* Schönherr in our literature in as much as the latter is a synonym of the former as stated by Klima (1934, p. 25). Sir Guy A. K. Marshall, dean of the weevil specialists, comments in a

letter, "With regard to *Tychius tomentosus*, Stephens recorded it under that name originally. Schönherr, without explanation, gave Stephens' specimens a new name, *stephensi* (sic), though admitting that he had not seen the specimens. In Schönherr's vol. 7 Boheman sunk *stephensi* as a synonym of *tomentosus* Herbst—quite rightly in my opinion."

It is regrettable that it is necessary to change the name of a species of economic importance in as much as the name *Tychius stephensi* has come into common usage in our literature. However, it is necessary to change the name in as much as *T. tomentosus* is a familiar species in Europe. The Rules of Zoological Nomenclature, Bulletin of Zoological Nomenclature, vol. 4, 1950, pp. 234-235, Conclusion 4(3) (a & b) are not applicable here.

I herewith propose the combination *Hamaba minima* (Blatchley), **new combination**, to replace the combination *Paragoges minimus* Blatchley. The species *minima* differs from the genotype of *Paragoges* LeConte by the deeply and widely cleft tarsal claws and sparser vestiture of broad lanceolate and setose scales. In *Paragoges* the claws are widely separated and simple, the vestiture very dense, the oblong scales overlapping. From the other species of *Hamaba* (Casey, 1910) it may be distinguished as follows:

1. Humeri reddish, the remainder of the elytra blackish; (Bahama Islands) *dispersa* Casey
- 1'. Elytra reddish brown to blackish, the humeri not paler than the remainder of the elytra 2
2. Range Florida and the Keys; base of elytra not to very feebly bisinuate; vestiture prostrate or nearly so *minima* (Blatchley)
- 2'. Range Bahama Islands; base of elytra rather strongly bisinuate; vestiture rather hispid, many scales semierect to erect *bahamensis* Casey

Petalochilinae

Previously *Nanus uniformis* Boheman (1844, p. 90) has been recorded from Cuba, Hispaniola, Puerto Rico, Guadeloupe, and with some doubt, from the United States. Five specimens were found in the trunk of a banana tree lying near the beach near Marco, Fla., IV-28-53, NJ & ELS. At first it was believed that these were recent immigrants, probably carried in the banana trunk from the Antilles, and were probably only temporarily introduced. However, two examples were later found in a dying banana tree near Fort Myers, Fla.

In 1952 Kuschel (p. 271) put the genus *Nanus* in the Petalochilinae. He based his removal of this genus from the Cossoninae to the Petalochilinae because the third elytral striae is united with the sixth striae apically rather than the eighth as in nearly all other Curculionidae. The structure of the striae is the key character used for separating the subfamily Petalochilinae from other subfamilies of the Curculionidae. Other characters Kuschel mentions are "the superficial scrobes, the considerable length of the anterior portion of the prosternum and the particular form of the femur." I fail to find a characteristic that could be termed superficial scrobes in most of the material examined. The prolongation or lengthening of the prosternum is present in all the material examined. The "particular form" of the femur apparently refers to the stoutness of the latter as they are rather prominently swollen in most of the material.

The genus *Hormops* LeConte also will have to be placed in the Petalochilinae as it has the characteristics of this subfamily. Kuschel also placed *Phyllotrox* Schönherr (genotype *semirufus* Boheman) and *Notolomus* LeConte (*bicolor* LeConte) in this subfamily. I have not examined specimens of *semirufus* (Brazil), but several species of *Phyllotrox* from Brazil and the Antilles have been studied and are found to possess the characteristics set forth by Kuschel. However, the species from the United States examined do not have the third and sixth elytral striae united apically. Thus, it would seem that they do not belong to either the genus *Phyllotrox* or the subfamily Petalochilinae. Due to the confusion surrounding the status of the species generically, the author is trying to obtain as much material as possible in order to revise the genus "*Phyllotrox*" of American authors.

Two hundred eighty-seven examples of *Notolomus bicolor* LeConte were examined and only five examples were found to have the third and sixth elytral striae united and in all of these the third was also united to the eighth apically. This also seems to be the case with *N. basalis* LeConte. Until more material in related genera is studied, it will be necessary to reserve an opinion as to the subfamily status of *Notolomus*.

Barinae

Stictobaris ornattella Casey was described from Tepehuanes, Durango, Mexico (1920, p. 347) from a female. A single male has been sent to the author from Calabasas, Ar., VII-15-42, A. W. Ford. It differs from the female only in the slightly stouter rostrum which is a little more densely punctured and in the slightly concave first and second abdominal sternites. It may be separated from the other species described from the United States by the following key:

1. Setae yellowish and white, condensed at the base of the third elytral interval and on intervals two to five in a rather large area behind the middle; body oblong. 2
- 1¹. Setae for the most part white, not in the least condensed at the points mentioned above. 3
2. Yellow setae of elytra narrower, much less robust than the white, the white slightly longer. *cribrata* (LeConte)
- 2¹. Yellow and white setae on elytra of same size, the white slightly longer. *ornattella* Casey
3. Body rather robust, oblong, obtusely rounded at elytral apex; rostrum densely punctured. *pimalis* Casey
- 3¹. Body narrow, rather narrowly rounded behind; size smaller; rostrum more sparsely punctured. *subacuta* Casey

S. ornattella Casey is narrower and less robust than the other species. The prothorax is not so closely, cribrately punctured as *S. cribrata* (LeConte). *S. cribrata* was described from Texas, recorded from Arkansas and known also from Kansas and Missouri. It has been reared from wheat heads. *S. pimalis* Casey was described from Arizona, *subacuta* Casey from Las Vegas, Nevada.

Pseudocentrinus ochraceus (Boheman) (1844, p. 237) has not as yet been recorded in any of our lists of Coleoptera of the United States. It was listed from the United States in both the Biologia Centrali-Americana (Champion, 1908, p. 326) and Blackwelder's checklist of Mexican, Central and South American, and West Indian Coleoptera (1947, p. 899).

The genus *Pseudocentrinus* Champion (1908, p. 325) may be defined as follows: rostrum stout, arcuate, moderately long; mandibles nearly straight along inner edge; antennal club oval, prothorax feebly constricted in front, broader than long; scutellum free; elytra a little wider than prothorax, narrowing from the rounded humeri; pygidium large, transverse, convex, vertical and fully exposed in the male, not visible in female; prosternum unarmed, sulcate; anterior coxae narrowly separated; abdominal sternite five transversely tumid in middle in female and sinuately truncate apically in male, 3 to 4 very short; femora unarmed; tarsal claws free, divergent, body elongate or oblong-rhomboidal, rather densely squamose. (Genotype: *Centrinus ochraceus* Boheman.) It was placed next to *Centrinogyna* Casey by both Champion and Casey because the apex of the pygidium is exposed in the males but not so in the females. This is a characteristic which *Centrinogyna* does possess, but the mandibles of the latter are dentate on the inner margin and the general form of that genus is more elongate and cylindrical. In our keys to the United States genera the males of *Pseudocentrinus* will key out near to *Odontocorynus* Schönherr because of the mandibular structure, exposed pygidium and general form, differing from that genus by the absence of the sexual modifications of the antennae. The females will key to *Geraeus* Pascoe, but differ from it in that *Geraeus* has the mandibles divaricate apically, with the inner margin more or less arcuate. It might be stated here that apparently the only species of *Geraeus* occurring in the United States is *Geraeus euryonyx* Champion (1910, p. 211) (*senilis* of Casey, 1892, p. 576, and *balteatus* Casey, 1920, p. 385) which occurs in Arizona and Mexico. From the generic description and the study of the genotype it would appear that *Pseudocentrinus* should be placed next to *Odontocorynus* in that both have similar mandibular structure and are very alike in general facies. It differs from that genus in that the former has the pygidium covered and the fifth abdominal sternite transversely tumid in the female; while the male lacks the sexual modification of the antennae; the prosternum in both sexes is abruptly sulcate.

P. ochraceus (Boheman) is elongate-rhomboidal in form; black to reddish black; densely squamose dorsally and ventrally; the prothorax with two darker vittae on the disc, the elytra with intermixed darker or ash gray scales, which are here and there condensed into patches. The rostrum is a little smoother in its apical half in the female than in the male, the antennae

inserted at about the middle in both sexes. The abdominal sternites 1 to 5 are broadly flattened down the middle in the male. Second funicular segment as long as 3 and 4 united. The elytra are flattened on the disc and have a rather prominent subapical callosity. The scutellum is moderately large and subquadrate.

Material from the United States has been studied from Brownsville, Texas (Wickham, USNM); Crystal City, Texas, I-14-50, J. R. Duncan, sweeping spinach, (USNM); Asherton (Dimmit Co.), Texas, I-15-53, C. E. Eastman, sweeping grasses, (ELS).

Rhynchophorinae

Scyphophorus acupunctatus Gyllenhal has previously been recorded with question from Florida. A single example was found on the flowers of sisal, *Agave sisalana* Perrine, Cape Sable, Fla., V-28-53, NJ & ELS, (ELS). Further examination of the plants failed to turn up additional specimens. *S. acupunctatus* occurs in southwestern United States, Mexico, and Central America. It has been found on this same sisal plant in Yucatan and another sisal in Nicaragua. In 1840, Dr. Henry Perrine introduced the afore mentioned sisal into the Florida Keys and the Everglades. It is quite possible that *S. acupunctatus* was introduced in some of these plants which were brought from the Yucatan.

Cosmopolites sordida (Germar) (1824, p. 299), a cosmopolitan species in the tropics, appears to have become established in southern Florida. Blackwelder (1947, p. 915) records it from the United States without definite locality. Six examples were collected from the same banana tree trunk as *Nanus uniformis* Boheman on the beach near Marco, Fla., IV-28-53, NJ & ELS. More examples were found at Flamingo (Cape Sable), V-2-53, NJ & ELS, and at Ft. Myers. At the latter locality it was also in the company of *Nanus uniformis* Boheman. Other examples have been sent by Dr. Howard V. Weems, Jr. of the Florida State Plant Board from Opalocka, G. B. Merrill; Fort Myers, IV-15-55, L. A. Hetrick, at *Musa*; Volusia, Miami, Larkin and Coconut Grove, all of these latter also from *Musa*. It is possible that many or possibly all of these latter were taken from imported bananas rather than domestic plants.

Cosmopolites Chevrolat (1885, p. 289) keys to *Rhodobaenus* in our keys to United States genera because the third tarsal segment is spongy ventrally and divided by a narrow line. It differs from *Rhodobaenus* in that *Cosmopolites* lacks the tooth or lamella next to the claw on the last tarsal segment; has the scutellum rounded and the elytral intervals strongly convex, occasionally the odd intervals are more prominently elevated than the even. The intervals are glabrous lacking the coating that covers the elytra and much of the ventral side. *Rhodobaenus* has a small tooth or lamella next to the claw on the last tarsal segment; scutellum elongate, triangular; all elytral intervals equal in elevation and flat. *C. sordida* is the only species in the genus.

Cossoninae

Dr. W. H. Anderson in 1952 (p. 305) pointed out that *Macrorhyncholus* Wollaston should be dropped from the North American lists in that the North American species there placed, *protractus* Horn, was not congeneric with the genotype or the exotic species placed in the group. He returned *protractus* to the genus *Rhyncholus* in which it was originally described. However, *protractus* Horn is not congeneric with the species of *Rhyncholus* differing from the North American species by the longer more prominent rostrum, the widely separated anterior coxae and the prominent (for Cossoninae) setae on the elytra. Because of the widely separated anterior coxae *protractus* must be placed in the Cossonini.

In 1954, while examining the Blatchley Collection at Purdue University I found that Blatchley had redescribed *protractus* Horn under the name *Trichacorynus sulcirostris* Blatchley (1928, p. 259) from "New Brunswick, N. J., X-8."

Hence we have *Trichacorynus protractus* (Horn), **new combination**, with *Trichacorynus sulcirostris* Blatchley a synonym, **new synonymy**.

Trichacorynus brunneus Blatchley, (genotype), (1916, p. 528) is apparently a valid species, distinct from *protractus* Horn, differing noticeably in that *protractus* has the head and rostrum more closely, evenly and deeply punctured and the anterior coxae not as widely separated.

Several examples of *T. protractus* have been received from York, Pennsylvania, VIII-18-22

Previously all records for *protractus* were from the west coast, chiefly southern California. These eastern examples of *protractus* may have been taken from timber recently brought in from California, it being quite possible that it is not even established in the east.

Dynatopechus aureopilosus (Fairmaire) (1849, p. 555) described from Tahiti has recently been collected at several localities along the west coast, and it would seem that it has become established in this country. The most recently collected examples were from Stevens Co., Wash., VIII-13-54, N. M. Downie. Material is also at hand from Barstow and Santa Barbara, California. An example is in the National Museum from Bakersfield, Calif., "Clothing, wooden jewelry." It is possible that the latter record was from jewelry imported from the South Seas.

The genus *Dynatopechus* Marshall (1931, p. 325) belongs to the Cossonini and may be separated from the other North American genera of the Cossonini by the five-segmented funicle. It should be placed between *Caulophilus* Wollaston and *Mesites* Schönherr.

Dynatopechus aureopilosus (Fairmaire) is black with two red stripes on the pronotum, a basal triangular red spot and a spot on each side of suture anterior to the declivity on the elytra, the legs reddish to reddish black.

Cossonus spathula Boheman (1838, p. 1035), which has been recorded from Central America and the Antilles, has been found on Cape Sable, Fla., IV-28-53, NJ & ELS, gumbo limbo. Two examples were found beneath the bark of a dead gumbo limbo tree. Further search failed to reveal additional examples. A single example has been received from "So. Fla." recently. It is also known from Cuba, Haiti, Puerto Rico, Jamaica, Grenada, Mexico, Central and South America. It may be distinguished from our other species of *Cossonus* by the very coarsely punctured prothorax and elytra and the very deep subapical constriction of the prothorax giving the appearance of a collar behind the head. This constriction is very noticeable even without the aid of a hand lens or microscope.

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INSOLUBLE RESIDUE STUDIES OF THE COLUMBUS AND DELAWARE LIMESTONES IN OHIO

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INTRODUCTION

Several generations of geologists have contributed to our knowledge of the Columbus and Delaware limestones of Ohio. Their studies include lithologic and paleontologic descriptions of these formations and, to some extent, attempt to subdivide them into smaller units. However, the work has been confined largely to areas of outcrop; little has been done on the subsurface identity and extent of these limestones. The purpose of this report is to describe, from insoluble residue studies of the outcrop areas, certain details of the petrography that may be used as criteria to aid in the correlation of the sections along the outcrop with those in the subsurface.

AREA STUDIED

The outcrop areas of the Columbus and Delaware limestones in Ohio are as follows (fig. 1): (1) a long, narrow belt extending north from northwestern Pickaway County to the region of Kelley's Island in Lake Erie; (2) an outlier in west central Ohio, mainly in Logan County; and (3) a strip in northwestern Ohio, west of the Cincinnati Arch, which includes beds of approximately Columbus and Delaware age. Locations of the sections studied are indicated on the map (fig. 1) and described in the appendix. Because most of these sections have been adequately described in previously published reports (Stauffer, 1909; Ehlers, Stumm and Kesling, 1951), they are not repeated in this paper. Reference to the published description of each section is included with its location in the appendix.

STRATIGRAPHY

The Columbus and Delaware limestones are commonly correlated with the Onondaga and Hamilton, respectively, of New York. In early geological reports on Ohio, this Devonian limestone section was referred to as the "Corniferous"; with later division of the section the term Columbus was introduced for the lower portion, and Delaware for the upper. A complete account of the origin, definition and use of the terms may be found in Stauffer (1909) and Stewart (1955). In his work on the Middle Devonian of Ohio, Stauffer divided the Columbus and Delaware limestones into zones based on lithologic and paleontologic characteristics. Since then, most workers have attempted some form of subdivision of the Columbus limestone but have left the Delaware a single unit. Subdivisions of the Columbus have generally included 2 or 3 units rather than the several zones of Stauffer, which are difficult to recognize except in central Ohio. Several names with various meanings have been used for these subdivisions; because of duplication and incomplete description, a summary of their history, with a suggested preference, is given here.

Bellepoint member, Columbus limestone

There is general agreement on the term Bellepoint member as applied to the lower Columbus of Ohio. Named by Swartz in 1907, from exposures in a quarry

and along Mill Creek at Bellepoint in southwest Delaware County, it consists of the brown dolomitic portion of the Columbus. The best exposures now are along the south bank of Mill Creek, about 200 yards east of an iron bridge $1\frac{1}{2}$ miles above the mouth. The base of the section is a conglomeratic layer, 6 inches to 1 foot thick, disconformably overlying Bass Islands dolomite. The top of the unit was placed by Swartz and Stauffer at the top of a coral-stromatoporoid biostrome, where it is present; the unit includes Stauffer's zones A, B, and C.

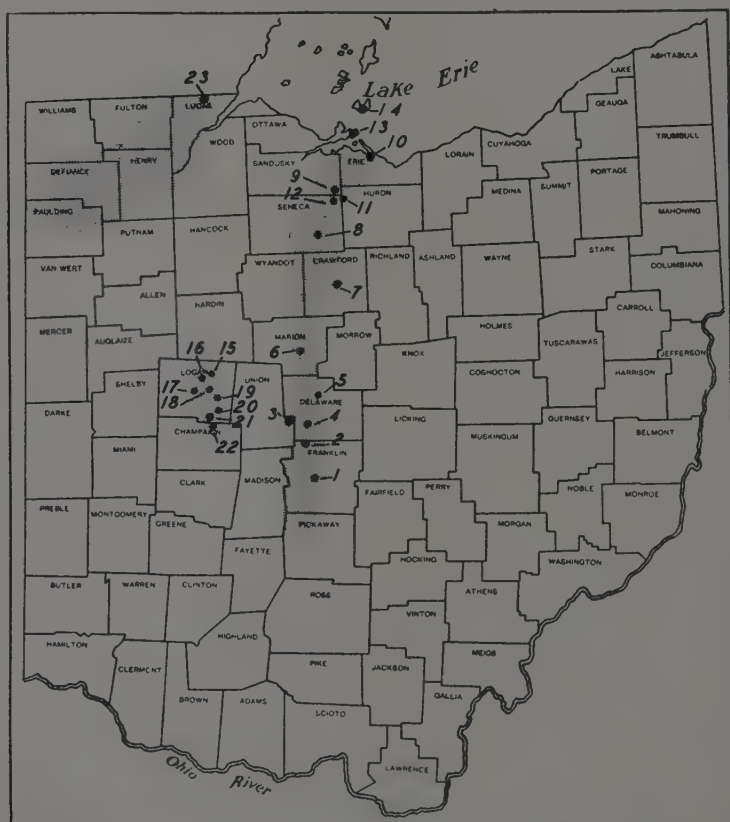


FIGURE 1. Map showing area of outcrop of Columbus and Delaware limestones and location of sections studied.

Delhi member, Columbus limestone

The designation of the upper member of the Columbus has had a more varied history.

The base of the upper part is a cherty limestone or a tan to gray crystalline limestone. The chert zone, also called the "gastropod zone," was named the

Eversole member by Stauffer, but he seems to have used the term more as one of convenience than as reference to a formal stratigraphic unit. This zone is not extensive in central Ohio. It is suggested here that the unit (Stauffer's D zone) be referred to as the gastropod or chert zone, where present, but not given a formal name.

In 1874 Winchell used the term Delhi for the high calcium limestone in the upper Columbus quarried near the village of Delhi (now Radnor) just northwest of Delaware, Delaware County. Winchell's description gave an erroneous impression of the thickness of the upper Columbus, as Stauffer later pointed out. Westgate (1926), in a report on the geology of Delaware County, called the upper Columbus Klondike, for exposures at Klondike quarry. However, he placed the base of the Klondike member about 6 feet above the top of the coral zone. He used the term "coral zone" for the biostrome layer, and "heavy limestone layer" or "*Spirifer macrothyris*" zone for the next 6 feet. In later papers Wells (1944, 1947) used first Klondike, then Delhi, for the upper member.

Swartz (1907) applied the term Marblehead member to the gray limestone in the Lake Erie area and Venice member to the overlying blue limestone. These two units, according to present interpretations, approximate the upper Columbus of central Ohio.

The Devonian limestone in the outlier in Logan County has been described by Stauffer (1909) and by Moses (1922). Stauffer identified the Monroe limestone, the Columbus limestone, and some Delaware (?) limestone overlain by the Ohio shale. In summarizing his results he indicated (1) a reduction or disappearance of the Bellepoint member, (2) a greatly reduced fauna, (3) a sandy upper zone in the limestone which may be Delaware, (4) the absence of a "bone bed" or other horizon marker for the separation of the Columbus and Delaware limestones, and (5) the absence of the Olentangy shale. He concluded that probably no separation of the Columbus limestone should be made. In the later study, Moses (1922) identified the Lucas dolomite, the Columbus limestone, and the Ohio shale. He divided the Columbus of the outlier into three parts on the basis of fossils and lithology, and suggested that the lowest part might be equivalent to Stauffer's zones A through D, and the middle part equivalent to the middle Columbus elsewhere. For lack of faunal evidence, Moses did not correlate the top part of the Columbus in the outlier.

Limestones that overlie the Detroit River group in Lucas County and adjoining areas of northwest Ohio have been called Columbus by Ohio geologists on the basis of (1) similar lithology, *i.e.*, dolomite in the lower part and limestone in the upper part; (2) similar sequence, *i.e.*, Detroit River, Columbus, and Traverse group of the west equivalent to Detroit River, Columbus, and Delaware-Olentangy of central Ohio; and (3) similar faunas. The "Columbus" of northwestern Ohio and the Dundee of Michigan are unquestionably the same unit; however, recent work on the fauna of this unit by Ehlers and Stumm (1951) and Ehlers, Stumm and Kesling (1951) suggests that the northwest Ohio "Columbus" is younger than the Columbus of central Ohio and therefore should be called Dundee. Stewart (1955), on the basis of an analysis of faunas, correlates the Dundee with the Delaware and leaves the Columbus interval unrepresented in the northwest Ohio section.

Since geologists generally agree to divide the Columbus limestone into two units, the following usage is suggested: Bellepoint member for the brown dolomitic, sparingly fossiliferous beds commonly called the lower Columbus, including Stauffer's zones A and B; Delhi member for the tan, gray, and blue fossiliferous limestone usually called the upper Columbus, including Stauffer's zones C through H. The coral, gastropod, and chert zones are considered zones in an informal sense. Because of its calcareous nature, abundant fossils, and sharp contact with the Bellepoint member, the coral zone is included in the Delhi member.

INSOLUBLE RESIDUE PROCEDURE

The thickest and most complete sections of the Columbus and Delaware limestones were selected for sampling and study. These sections were measured, and samples were taken at one-foot intervals. Most samples were selected from the limestone matrix rather than from a chert nodule, a coral, a stromatoporoid, or a clayey layer. Residues from the samples not thus selected contain a large amount of chert or clay, most of the latter reflecting the position of a clayey bedding plane or a stylolitic surface. Wherever possible, samples were selected from fresh rock.

Laboratory processing for the insoluble residues followed generally a technique used at the Illinois State Geological Survey by L. E. Workman (personal communication). A 20- to 25-gram sample of approximately pea-sized fragments was dissolved in a beaker of dilute hydrochloric acid. Some samples required heating in a sand bath for complete digestion of dolomite. The liquid was decanted and the residue washed to remove the acid. In the process of washing, agitation, and decanting, the portion of the residue finer than about 0.01 mm. was collected on filter paper. By careful and consistent handling, this size separation was kept reasonably constant. The coarse and fine residues were weighed and the quantity of each shown on graphs (see Moore, 1951; Jackson, 1952; and Struble, 1952). The coarse residue was described in detail. Although in the solution of many of the samples, an organic residue collected on the surface of the acid, no effort was made to determine its nature or quantity, and in the removal of this rather gummy substance undoubtedly some of the inorganic particles were lost. A generalized summary graph for each area studied is included here (fig. 2, 3, 4, 5).

LITHOLOGIC DESCRIPTION

A generalized section is briefly described for each of the outcrop areas. Outcrop sections of the Columbus limestone are thickest in central Ohio. The thickness has been variously reported: Stauffer (1909) estimated 105 feet; Carman (1927) measured 87 feet at O'Shaughnessy Dam; Westgate (1926) estimated 85 feet in the Delaware County area.

The Bellepoint member lies disconformably on the Bass Islands group, as can be seen at the type locality along Mill Creek in southwest Delaware County. The Bellepoint is a porous brown medium-grained dolomite. At the base is a conglomeratic interval of 6 to 8 inches, containing pebbles of tan to gray fine-grained dolomite and chert up to 3 inches in diameter. The pebbles are lithologically like the immediately underlying Bass Islands and Detroit River groups. The matrix of the conglomeratic interval is very sandy in most places, the sandiness persisting upward for 2 to 3 feet. The major portion of the Bellepoint member consists of brown and tan medium-grained dolomite in beds 6 inches to 3 feet thick, containing many well-developed stylolites whose surfaces are covered by a black asphaltic residue. Considerable recrystallization is indicated by ghost outlines of fossils and large areas of uniformly oriented grains having a common cleavage direction. Nodules of white to gray chert are present, usually scattered but occasionally in layers. The upper portion of the Bellepoint is more calcareous, and a clayey band makes a sharp break between it and the overlying Delhi.

Ranging in thickness from about 55 to 65 feet, the Delhi member in central Ohio is a medium to coarsely crystalline fossiliferous limestone containing chert in layers and scattered nodules, and numerous stylolites. The color varies from almost white through gray to tan. The lithology of the base of the Delhi is variable: In some areas it is a coral-stromatoporoid biostrome up to 4½ feet thick; the matrix is light brown fine-grained limestone with clayey layers at top and bottom and occasionally scattered through the unit; in places the corals are highly stained with petroleum residue, and heavy black residues are found on

some bedding surfaces. In other areas the lowest Delhi beds contain up to 8 feet of white to gray chert, in nodules, layers, or large masses, some of which are brecciated; they are also fossiliferous, with gastropods particularly common. In still other areas the base of the Delhi is tan fine- to medium- grained limestone.

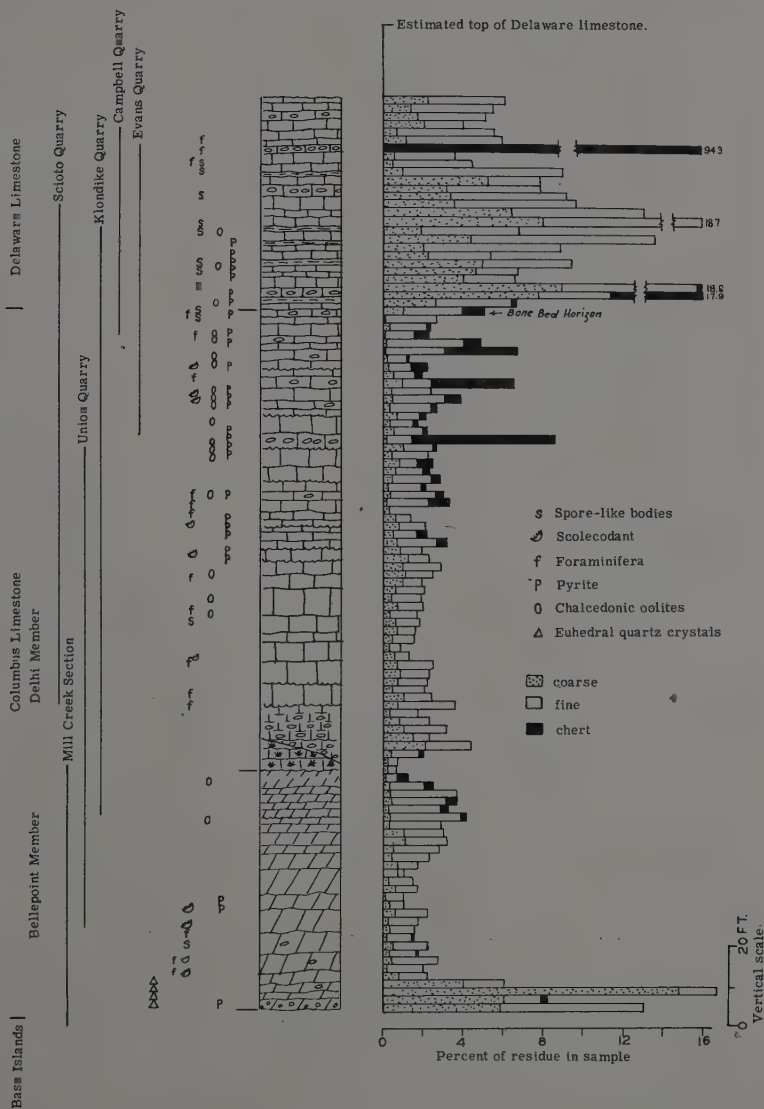


FIGURE 2. Generalized section of the Columbus and Delaware limestones in central Ohio, showing the distribution of insoluble residues.

These lower beds are overlain by light tan to gray thick-bedded limestone containing many fossils. Some layers, notably Stauffer's "*Spirifer gregarius*" zone, are almost a coquina. The upper 15 to 20 feet of the Delhi is somewhat less fossiliferous, medium to massive bedded with prominent oblique joints and scattered white to buff nodules near the top. At many localities the top of the Delhi member is marked by a "bone bed," described in detail by Wells (1944). This bed is approximately 6 to 10 inches thick, but bone material is abundant in places as much as 2 feet below the top of the member. The matrix is tan to gray coarsely crystalline limestone, in some places crinoidal.

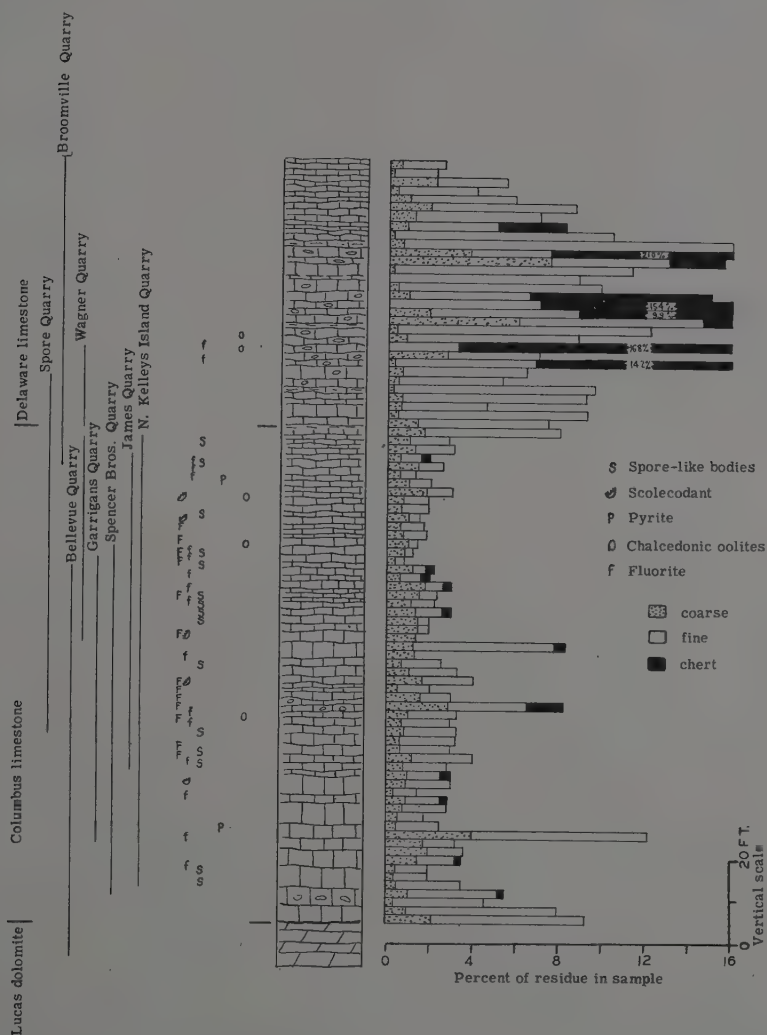
Disconformably overlying the Columbus limestone is the Delaware limestone, which in central Ohio is approximately 35 feet thick. At the base of the Delaware in the Columbus area, the limestone is fine grained, bluish gray, and shaly, with a prominent chert interval about 8 feet above the base. Higher in the section the chert is less prominent, and most of it occurs as regular nodular layers about 1 inch thick. The formation contains less chert northward from the Columbus area. The major portion of the Delaware is fine- to medium-grained blue-gray fossiliferous limestone. Occasional layers of crinoidal limestone occur, one of which is at the position of Stauffer's *Hadrophylum* zone, also the horizon of a bone bed. Upon weathering, the blue-gray color of the fresh limestone typically becomes brown, and originally massive-appearing beds separate into thin beds. The Delaware limestone is disconformably overlain by the Olentangy shale.

The Columbus limestone changes in character and thickness northward toward the Bellevue-Sandusky area. The basal beds of the Columbus, where it disconformably overlies the Lucas dolomite, are less conglomeratic and less sandy than those in central Ohio. These beds are tan to gray limestone or dolomitic limestone and are coarser grained than the light, fine-grained Lucas beneath. The lower and middle portions of the Columbus in the Bellevue-Sandusky area are similar to corresponding portions of the Delhi member of central Ohio. The upper 20 feet, however, is blue-gray, and is less fossiliferous and more compactly crystalline than that to the south. The Columbus limestone of northern Ohio is nowhere completely exposed; from the correlation of several quarry sections, it is estimated to be about 60 feet. The decrease in thickness is interpreted as the result of overlap from the south, with loss of the Bellepoint member; paleontologic evidence supporting this interpretation is discussed in Ehlers and Stumm (1951). Thus the Columbus limestone of the northern area is thought to be the equivalent of the Delhi member of central Ohio.

The overlying Delaware limestone also changes toward the north. It is thin to medium bedded, blue to blue-gray, medium grained, and fossiliferous. Here the lithology of the lower portion of the Delaware is similar to that of the underlying upper portion of the Columbus. Interbedded with the crystalline limestone are numerous layers of crinoidal limestone, occasionally shaly. Most of the chert is gray to black and in nodular layers; some is white and usually fossiliferous. Stauffer identified the Columbus-Delaware contact at several localities on the basis of a "bone bed" horizon, which is not so well developed as the one in the Columbus area, but seems to be in about the same position. The complete Delaware section is not exposed; an estimate of the thickness, based on correlation among several quarries, is 60 to 70 feet. It is overlain by the Plum Brook shale.

Devonian rocks of the Bellefontaine outlier include Lucas dolomite, Columbus limestone, and Ohio shale. Stauffer reported questionable Delaware limestone in several places, but his identification does not seem warranted. The total thickness of the Columbus in the outlier is estimated to be approximately 85 feet. This is the interpretation of Moses (1922), who, on the basis of fossils, placed the section at Cable below the sections at Bellefontaine and East Liberty. The maximum known thickness at any one place is approximately 65 feet, based on an interpretation of cuttings from a water well at a military installation on Campbell Hill (cuttings are on file at the Ohio Geological Survey).

The lower part of the Columbus section at Cable consists of a sandy, somewhat conglomeratic interval at the base of light brown fine- to medium-grained dolomite, with a well-developed chert interval a few feet above the base. The chert is somewhat massive, white to tan, and fossiliferous. The remainder of the section is gray medium-grained dolomite and dolomitic limestone, with some fossiliferous limestone toward the top. This section overlaps a fine-grained dolomite identified as Lucas.



The contact of the Lucas dolomite and the Columbus limestone is exposed in the lower part of a quarry at the west edge of Bellefontaine. In this quarry the Columbus is massive, tan to gray, medium-grained dolomite with scattered chert nodules and fossils and with a 4-inch chert layer at the base. Fish teeth are common in the lower 2 to 3 feet. The upper part of the Columbus is best exposed in the East Liberty quarry. It is medium-grained, tan to gray-buff dolomite, dolomitic limestone, and limestone, somewhat massive but weathering into thin beds. It contains numerous stylolites and white and buff chert nodules scattered or in layers. Toward the top is a 1- to 2-foot bed of white to purplish fossiliferous chert associated with layers of crinoidal limestone. The upper 1 to 3 feet are gray to brown and sandy, with occasional bone fragments. The top surface has large areas of pyrite 1 to 2 inches thick, overlain by Ohio shale.

The Columbus(?) (Dundee) of the Lucas County area was studied only at the France Stone Company quarry at Silica, Ohio, where it is approximately 60 to 65 feet thick. It disconformably overlies the Detroit River group (Anderdon) and at the top is transitional with the overlying beds, which are called the "Blue" limestone member (Carman, personal communication) of the Silica formation. The lower 20 feet of the formation in the quarry are tan to gray thick-bedded medium-grained dolomite and dolomitic limestone, with scattered fossils, some stylolites, and chert. The chert is especially abundant in the lower 4 to 5 feet; it is nodular, white, and fossiliferous in places. The middle part of the section is buff and gray medium-bedded fossiliferous limestone with scattered chert nodules. The upper portion is thin- to medium-bedded tan and gray fossiliferous limestone. The general lithologic appearance of the formation is similar to that of the Columbus of central Ohio, but the faunal interpretation of Ehlers, Stumm, and Kesling (1951) correlates it with the Delaware.

DISTRIBUTION AND DESCRIPTION OF INSOLUBLE RESIDUES

The insoluble residues are discussed in somewhat arbitrary groups: detrital minerals—fine and coarse fractions; secondary minerals—chert, euhedral quartz, pyrite, and fluorite; and organic materials. The stratigraphic distribution of residue by percentage is summarized in figures 2, 3, 4, and 5, in generalized columns for each area studied. Graphs of the residues show the percentages of fine clastics, coarse clastics, chert, and pyrite; symbols indicate the distribution of pyrite in small quantities and of arenaceous foraminifera, scolecodonts, and spore-like bodies. Detailed descriptions of the residues by section are available in the theses of Jackson (1952), Moore (1951), and Struble (1952).

Detrital minerals—The detrital minerals of the residues were separated into fine and coarse fractions.

The fine residue consists of clay and fine silt-size grains of quartz, chert, and clay minerals; no attempt was made to identify it further. Quantities of fine residue from the Columbus limestone vary as follows: in most samples they range from 2 to 4 percent; individual samples, however, run as high as 8 percent, the cause in most cases being a clayey bedding plane or stylolitic surface at the position where the sample was taken. Clayey layers in the coral zone may run higher than 10 percent. Quantities of fine residue vary little between the upper and lower Columbus. A slight increase exists in the Columbus of the outlier, the general range there being from 3 to 5 percent. Quantities of fine residue in most samples from the Delaware limestone range from about 8 to 10 percent; individual samples contain as much as 20 percent. Since both a greater quantity and a greater range in quantity of fine material are found in the Delaware than in the Columbus, the contact between the two limestones is well marked.

The detrital portion of the coarse residue is made up of binodal quartz sand with traces of accessory minerals. The sand is of two types, with a distinct size separation. The coarser type (fig. 6, A) is fine to medium, well rounded, and

frosted, and contains some inclusions; the finer (fig. 6, B) ranges from medium silt to very fine sand and is angular to subangular. The stratigraphic positions of the coarser type are distinctive: it occurs at the base of the Devonian, whether the lowest Devonian formation be Detroit River or Columbus; at the base of the coral zone (base of upper Columbus); and at the top of the Columbus in the East Liberty quarry of the outlier. It is generally best developed at the base of the Devonian, where it is as much as 3 feet thick; an exception, however, is at the Piatt quarry in Logan County, where the sandy character persists throughout the 23 exposed feet of the Lucas formation. The sandy interval at the base of

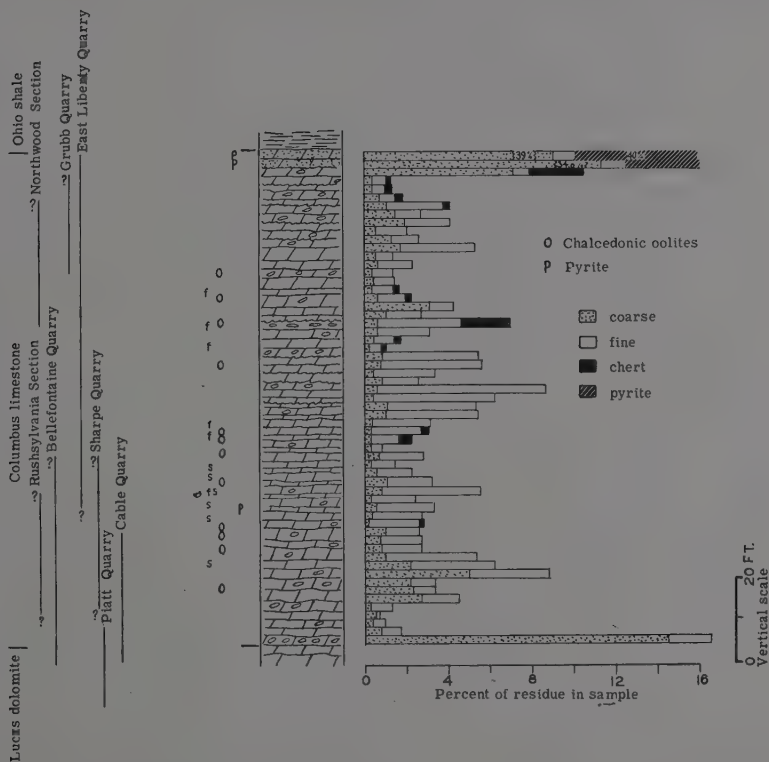


FIGURE 4. Generalized section of the Columbus limestone in the region of the Bellefontaine outlier, showing the distribution of insoluble residues.

the Columbus where it overlies the Detroit River is 1 to 2 feet thick. These intervals at the base of the Lucas and at the base of the Columbus are well shown in the section from a water well on Campbell Hill in the area of the Bellefontaine outlier (see O.G.S. well sample No. 475). Coarse frosted sand was found at the coral zone, *i.e.*, the contact between the upper and lower Columbus, in two sections in central Ohio, but there is less there than in the lower sand intervals. In the East Liberty quarry section in the outlier, frosted grains are present in the top 2 feet, where the limestone becomes impure. This is the position of the beds which Stauffer suggested might possibly represent the Delaware. In other than

these intervals, one to five coarse frosted grains per sample were found in scattered samples throughout the Columbus, but none were in those from the Delaware.

The finer silts and sands of the coarse residue range from less than 1 to 2 percent in most residues of the Columbus limestone; a few samples contain as much as 5 percent. In the Delaware limestone, the finer sand and silt fraction increases sharply to an average of 4 to 6 percent; in some samples it is more than 10 percent. This increase in quantity of the silt to fine sand parallels the increase of the finer (clay to fine silt) fraction in the Delaware residues.

Included with the detrital grains are a number of accessory minerals, most of fine sand and silt size, some angular and some rounded. The more common of these, in order of decreasing quantity, are zircon, tourmaline, feldspar, leucoxene, ilmenite, limonite, hematite, magnetite, and garnet. None of these minerals are present in quantities greater than a trace, and no identifiable pattern appeared in their distribution, either laterally or vertically.

Secondary minerals—Secondary minerals in the residues include various forms of chert, euhedral quartz, pyrite, and fluorite.

The term chert is used here to refer to mixtures of several varieties of silica, from chalcedony to cryptocrystalline quartz to macrocrystalline quartz. Chert is present in about half of the residues studied. The quantity varies widely from sample to sample. Since deliberate effort was made to avoid the larger masses of chert in sampling, percentages given here do not represent completely the distribution of chert in the formations. It was noted in the field that chert horizons vary even within a single quarry. A few observations on the general character and distribution of the larger chert nodules can be made here, but further study of the chert is needed.

In general, chert of the Columbus is light, varying from light gray to white and from cream to buff. More often than not it occurs as scattered, discontinuous nodules. Much of it is fossiliferous. In the Columbus of central Ohio, chert is found near the base and the top of the Bellepoint member, in the "chert zone," and near the top of the Delhi member. In the "chert zone" it is gray to white, massive, fossiliferous, and in many places brecciated. The Columbus of the outlier seems to contain more chert than does that of central Ohio, and more of it occurs in layers. A well-developed fossiliferous chert layer is present near the base of the Cable section, and another near the top of the Columbus in the East Liberty quarry. Chert is found in the lower part of the Columbus in northern Ohio and in the lower part of the Columbus(?) in Lucas County.

The chert of the Delaware is in well-defined, nodular layers, more continuous than those of the Columbus. It is typically gray to black, although some of it is lighter in the middle and upper parts of the formation. One type of nodule, particularly characteristic of the Delaware, is composed almost wholly of fossil fragments, largely bryozoa. Less chert is found in the Delaware of northern Ohio than in that of central Ohio.

Chert in the residues occurs in a number of forms: as massive chert fragments, some of which contain fossils; as porcelainous, porous, white chalcedony; as chalcedonic oolites; as fossil casts of granular quartz; and as fossil casts of massive quartz.

The massive chert fragments vary in color and structure; they are white to gray to tan, and many contain small druse-filled cavities. They occur irregularly in the residues from both formations, representing portions of larger nodules which were included in the original sampling.

The white porous chalcedony occurs as fossil replacements, usually fragmentary; as large, irregular masses; and as fine sand- and silt-size fragments. This type of chert occurs in both the Columbus and the Delaware limestones but is more common in the Delaware.

Chalcedonic oolites (fig. 6, C) are well developed in many of the samples from all sections of the Columbus. Many of the oolites are clustered; some individuals

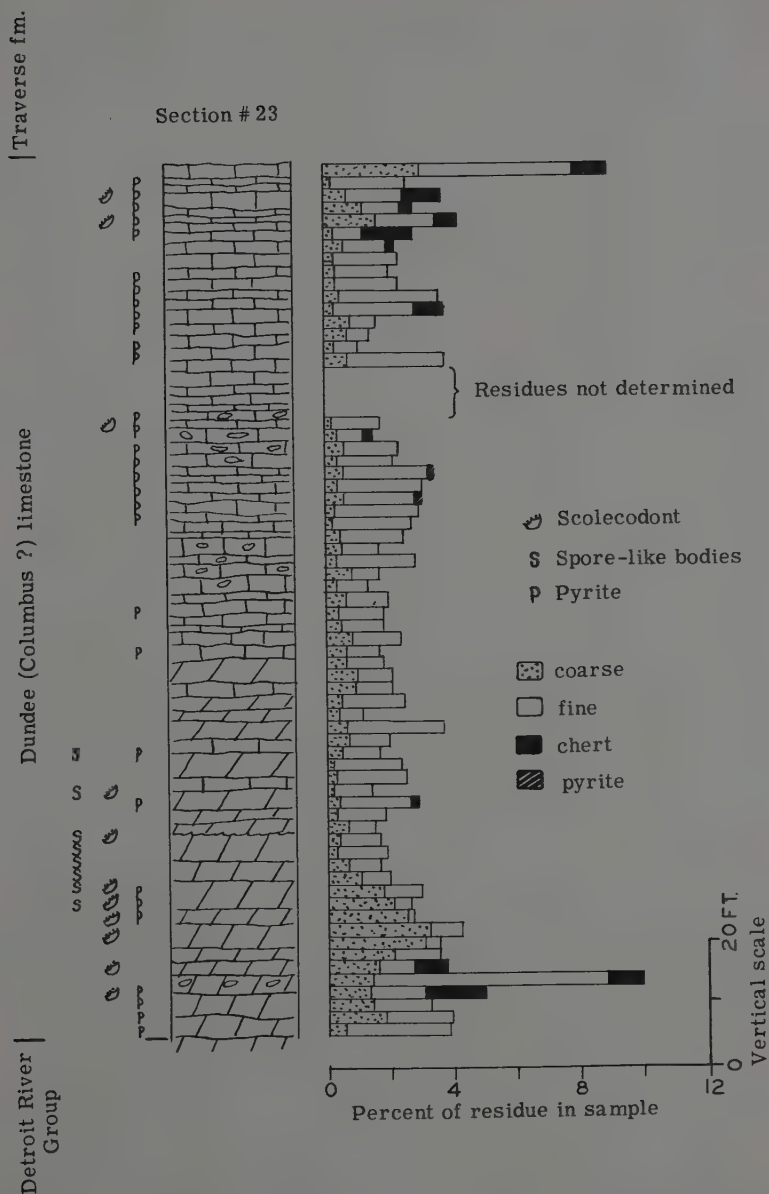


FIGURE 5. Generalized section of the Dundee (Columbus?) limestone from the Silica quarry, Lucas County, Ohio.

are large enough to be called pisolites. Some are light gray, waxy, semi-translucent chalcedony; others are varying shades of porcelainous white chalcedony; still others are altered to spheres of clear granular quartz. These oolites and pisolites are believed to be of primary origin, for the samples contained no evidence of calcareous forms. In many of the larger fossil fragments the structure of the main mass is of massive quartz; the borders are chalcedonic and have a concentric structure like that of oolites, thereby suggesting that they represent the most recent growth (fig. 6, D). Both clustered oolites and fossil replacements were observed in residues from Mississippian limestones of Indiana by Martin (1931), who used the term "ooloid" to describe them. Although most authors believe that chalcedonic oolites are secondary replacements of original calcareous forms, both the Columbus forms described here and the Mississippian forms described by Martin suggest that these are primary structures. There appears to be a sequence of changes from the chalcedonic form to the granular silica in many of the oolitic clusters and fossil casts in the residues.

Although such oolites are occasionally found in the lower Columbus, they are particularly characteristic in the upper Columbus of all areas. Fragmentary fossil casts, usually made up of somewhat massive crystalline quartz or granular quartz (fig. 6, E), are numerous. Both types may be a result of recrystallization of "ooloids" of chalcedony. These fossil casts are one of the most common forms of chert in the residues. They occur in all units, but are especially characteristic of the upper Columbus, where they constitute the major portion of many of the coarse residues. Because the quantity of chert varies so greatly, composition, color and structure of the chert are more distinctive than amount.

Euhedral quartz is present as regenerated rounded detrital grains and as authigenic crystals, doubly terminated or in clusters (fig. 6, F). Secondary growth exists on the finer, subangular grains of the residues, but no pattern of distribution has been recognized. Grains showing secondary growth are common in the sandy Lucas dolomite in the Piatt quarry. Authigenic quartz is found in the sandy interval at the base of the Columbus in three localities.

Pyrite occurs in crystals from 0.01 to 0.1 mm., crystal aggregates, mat-like masses, and partial replacements of fossils. Its distribution in the formations is irregular both vertically and horizontally. In about half the samples it occurs as a trace of very small crystals; more rarely, as larger crystals or fossil replacements. It is most abundant at the top of the Columbus in the Bellefontaine outlier and near the contact of the Columbus-Delaware limestones elsewhere. In places the lower third of the Delaware has a slightly larger pyrite content than is generally found in the Columbus. Pyrite in small crystal particles and crystal aggregates is common in the northwest Ohio section.

Fluorite occurs in many of the residues from northern Ohio in the form of irregular crystalline masses, inclusions in chalcedony, and crystalline clusters with well-developed cubes (fig. 6, G). It is light purplish-tan to light purple. Fluorite is most common in the more porous, fossiliferous beds of the middle and upper parts of the Columbus. Distribution is not limited to any specific horizon; occurrence, however, is limited to the northern area.

EXPLANATION OF FIGURE

FIGURE 6. Examples of some characteristic materials found in the residues from Columbus and Delaware limestones. (All photographs N13.) A. Frosted sand. B. Fine angular sand. C. Chalcedonic oolites. D. Ooloid structures partially replacing brachiopod shell. E. Granular quartz casts of sponge spicules, bryozoan, and erinoid plates. F. Euhedral quartz. G. Crystalline clusters of fluorite. H. Arenaceous foraminifera. I. Sclerozooids. J. Unidentified spore-like bodies.

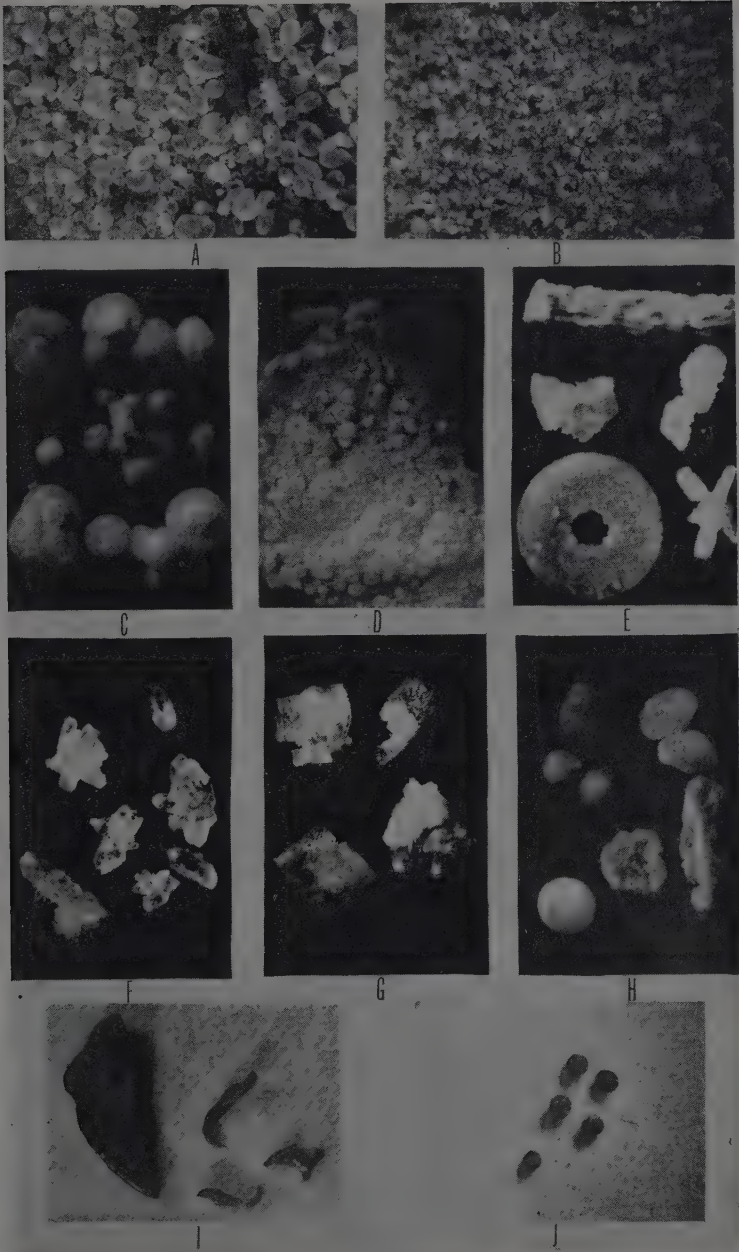


FIGURE 6

The organic portion of the residues includes bituminous material and fossils. Bituminous material emerges as a scum on the acid of a majority of the samples. It also occurs in small plate-like masses in a mixture with clay and silt fragments; in this form it is found spottily throughout both formations, but is most common in the lower Columbus and the Delaware. Fossils in the residues include arenaceous foraminifera, scolecodonts, fish plates, unidentified spore-like bodies, and chalcedonic or quartz aggregate casts of crinoid parts, corals, brachiopods, sponge spicules and others. Arenaceous foraminifera (fig. 6, H), although more numerous in the central and northern areas than in the outlier, are fairly common throughout the Columbus; they represent several genera and species, including some that are new. Only a single small flattish form was found in the Delaware. Scolecodonts (fig. 6, I) show no strong stratigraphic or areal distribution. The unidentified spore-like bodies (fig. 6, J) are small brown to black hollow spheres approximately 0.03 mm. in diameter. They are abundant in certain samples from both the Columbus and the Delaware, particularly those of northern Ohio and Lucas County. Similar forms have been observed in the Onondaga of New York by J. F. Pepper (personal communication). The residues contain a few fish plates, most frequently from the position of the Columbus-Delaware boundary.

Fossil replacements by quartz crystal aggregates and by chalcedony appear in many of the residues. Although several invertebrate groups are represented, the preservation is so incomplete as to make identification of genera or species unlikely. Most of the fossil casts are concentrated at certain horizons, but these horizons occur in both Columbus and Delaware limestones. Casts formed of quartz crystal aggregates are the more common; most of them are crinoid fragments. Typically, the casts occur in the more fossiliferous beds of the upper Columbus and, to a lesser degree, in the upper third of the Delaware. The more massive quartz and chalcedonic casts may be present at certain horizons in any part of either formation. Sponge spicules of quartz crystal aggregate are especially common in the horizon of the "bone bed."

Features of the residues that offer possible means of distinguishing between the Columbus and Delaware limestones can be summarized thus:

Residues of the Bellepoint member are rather consistent in quantity of fine detrital material, silt, and fine sand. An interval of frosted sand occurs at the base. Some chert and a few chalcedonic oolites are present. Bituminous stain is prevalent, and there are scattered arenaceous foraminifera and scolecodonts.

Residues of the Delhi member contain detrital material in quantities similar to those of the Bellepoint, with a less well-defined interval of frosted sand at the base. Chert is common in the form of chalcedonic oolites and fossil casts. Fossil casts composed of quartz crystal aggregates are characteristic of this member. Numerous and varied forms of arenaceous foraminifera are present.

Delaware residues show a marked increase in the amount of detrital material of clay, silt, and fine sand size. The increase is consistent throughout both the central and the northern areas. Detrital material is less, however, in the upper part of the formation, and a limited number of samples might therefore be confused with the Columbus. The Delaware is also distinguished by a near absence of foraminifera and chalcedonic oolites.

Residues of the Lucas County section studied as a basis for comparison include most of the characteristics of the upper Columbus residues. The overlying Blue limestone is an argillaceous unit, and although sampling was not continued beyond the top of the Columbus(?), this argillaceous character should result in an increase of detrital material at the Columbus(?)-Blue contact similar to the increase at the Columbus-Delaware contact elsewhere. Nothing in the characteristics of the residues suggests that the Lucas section could not be correlated with the upper Columbus of central Ohio, despite apparent absence of arenaceous foraminifera.

EVALUATION FOR POSSIBLE USE IN SUBSURFACE CORRELATION

Residues of the Columbus and Delaware formations contain enough characteristics in common that if one were given a single residue it would be difficult, if not impossible, to identify the formation from which it came. However, if a vertical sequence were available, a subdivision of the section could probably be established.

The materials described here have been from surface outcrops. What might be the potential use of the criteria given for each formation in subsurface correlation?

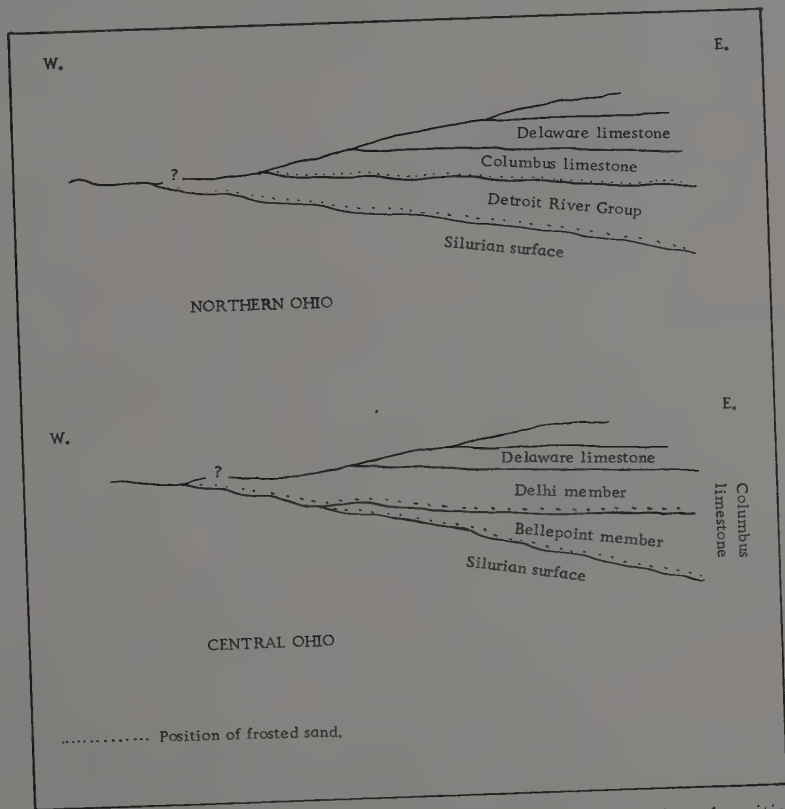


FIGURE 7. Diagram showing possible relationships of various frosted sand positions to the Silurian surface.

The stratigraphic positions of the frosted sand grains are the most outstanding feature of the residues. The origin of such grains in the Hillsboro and Sylvania sandstones has been discussed by Carman and Schillhahn (1930) and Carman (1936). The sandy interval at the base of the Devonian in central Ohio and northward to the Lake Erie islands is interpreted as a thin extension of the sand deposits of those two formations. Because of the relatively wide distribution of this sandy interval in surface exposures, it may be expected to persist for some distance in the subsurface.

A complication arises in that as many as three sandy intervals may have been developed; but, since the two additional intervals, at the base of the Columbus above the Detroit River and at the base of the upper Columbus, are probably less extensive, experience should allow one to distinguish among them. Although all of these sandy deposits represent further transgressions of Devonian seas (fig. 7), the lowest, marking the initial inundation of the sand-covered Silurian surface in this area, not only is the best developed but also should be the most extensive. The upper sand intervals representing westward overlap of successive Devonian seas probably had a more limited supply of sand and a more limited distribution into the basin. How far these intervals do extend and how they are related to the sand intervals reported as "Oriskany" in the well records remains to be determined.

The sandy character of the Lucas at the Piatt quarry and the sandy interval at the top of the Columbus at East Liberty, both in the outlier, have not been found in central and north central Ohio. Their location suggests a land area to the west and southwest that persisted to the end of Columbus time. This land might be an expression of the island referred to as Cincinnati by Wells (1944). Sections throughout which sand is persistent, as in the Lucas of the Piatt quarry, can be explained by nearness to the shoreline, which remained in that locality throughout the deposition of the unit.

Other characteristics of the residues may also be pertinent to the problems of subsurface correlation:

First, the increase of detrital material at the Columbus-Delaware contact may be significant. If the generally accepted correlations of the Columbus with a portion of the Onondaga limestone sequence of New York and of the Delaware with the Hamilton shales and limestones of New York are correct, this difference in the detrital content of the two formations should not only persist but also increase to the east in the subsurface.

Second, although chalcudonic oolites may be of secondary origin and their distribution limited to the outcrop or near outcrop areas, it is also quite possible that they may be of diagenetic origin; if so, they may be widespread and therefore useful eastward in the subsurface. Newell (1953, p. 173) discusses this problem in relation to the siliceous replacement of fossils in the Permian limestones of West Texas.

Third, although the presence or absence of arenaceous foraminifera with chance recognition of them in the small samples from wells would hardly be very diagnostic in itself, as corroborative evidence it would be useful.

CONCLUSIONS

The insoluble residues of selected sections of the Columbus and Delaware limestones show that each formation has certain characteristics by which it can be recognized. Several lithologic features, particularly sand intervals and variation in quantity of clay-silt content, may be used to trace certain horizons eastward as an aid in subsurface correlation.

ACKNOWLEDGMENTS

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APPENDIX

Locations of Sections Studied

The longer sections of the Columbus and Delaware formations are limited to quarries, and almost all sections studied have been described in previous publications. Therefore, to avoid repetition, only location and reference to sections are given here. Sections are in order of occurrence on the index map (fig. 1).

1. *Marble Cliff Quarries.* Section is in Marble Cliff Stone Company quarry north of Trabue Road, about a quarter of a mile west of Scioto River, west of tunnel connecting quarries north and south of Trabue Road, Norwich Township, Franklin County (West Columbus quadrangle). Section includes about 50 ft. of Columbus limestone and about 10 ft. of Delaware. It is the same as that described for the area by Stauffer (1909, pp. 44-49).
2. *Mill Creek Section.* Section is at a prominent bluff near an iron bridge across Mill Creek, 1 mile west of Bellepoint, Delaware County (Dublin-Delaware quadrangles). Section includes base of Columbus and approximately 30 ft. of Bellepoint member. Described by Stauffer (1909, pp. 73-74).
3. *Union Quarry.* Quarry is 2 miles east of Watkins, Mill Creek Township, Union County (Dublin Quadrangle). Section includes about 22 ft. of Bellepoint member and about 43 ft. of Delhi member. Coral zone is well developed at this locality.
4. *Klondike Quarry.* Quarry is on east side of Scioto River in Scioto Township, Delaware County, about 2 miles north of Bellepoint (Delaware quadrangle). Section starts in stream valley along south edge of quarry approximately at level of Scioto River and continues up valley and up face of quarry. It includes about 14 ft. of Bellepoint member and all of Delhi member of Columbus limestone. Described by Stauffer (1909, pp. 74-75).
5. *Campbell Quarry.* Section is in abandoned Campbell quarry at Delaware, Delaware County (Delaware quadrangle). Quarry is in center of west side of town, where abandoned Hocking Valley Railroad crosses Delaware Run. Twenty-five ft. section is all Delaware limestone. Described by Stauffer (1909, p. 87).
6. *John Evans Quarry.* Quarry is in northwest Marion, Marion County (Marion quadrangle), at intersection of Fairground Street and Hocking Valley Railroad. Quarry is partially filled with water, but about 34 ft. of section are exposed, including 13 ft. of Columbus and 21 ft. of Delaware. Described by Stauffer (1909, pp. 94-95).
7. *Spore Quarry.* Quarry, owned by Broken Sword Stone Company, is located along Broken Sword Creek about 6 miles northwest of Bucyrus, near Spore, Holmes Township, Crawford County (Sycamore quadrangle). Section includes some 42 ft., of which 36 are Columbus limestone, and the remainder Delaware limestone. Described by Stauffer (1909, pp. 109-110).
8. *Bloomville Quarry.* Section is in abandoned France Stone Company quarry about 1 mile north of Bloomville, Bloom Township, Seneca County (Tiffin quadrangle). Section contains about 36 ft., of which about 5 ft. are Columbus and the remainder Delaware. Described by Stauffer (1909, p. 111).
9. *Bellevue Stone Quarry.* Bellevue Stone Company quarry is located on north side of U. S. Highway 20, west of Bellevue, York Township, Sandusky County (Bellevue quadrangle). Section includes about 40 ft. of Columbus limestone, overlying probable Lucas dolomite. Described by Stauffer (1909, p. 114).
10. *Garrigan's Quarry.* Abandoned quarry is about $1\frac{1}{2}$ miles west of Bellevue (Bellevue quadrangle) between U. S. Highway 20 and New York Central Railroad. Section consists of 31 ft. of Columbus limestone.
11. *Spencer Brothers Quarry.* Quarry is about 2 miles southwest of Bellevue along Nickle Plate Railroad in southwest quarter of Section 35, York Township, Sandusky County (Bellevue quadrangle). Section consists of about 40 ft. of Columbus limestone. Described by Stauffer (1909, p. 113).
12. *Wagner Quarry.* Wagner quarry section is located across road from south corner of Soldiers' Home in southeastern Sandusky, Erie County (Sandusky quadrangle). Section includes about 33 ft., of which upper 8 are Delaware and remainder Columbus limestone. Described by Stauffer (1909, pp. 125-126).

13. *James Quarry.* James quarry section is south of railroad station at Marblehead, Danbury Township, Ottawa County (Kelley's Island quadrangle). Section consists of 27 ft. of Columbus limestone. Described by Stauffer (1909, pp. 134-135).
14. *North Quarry.* North quarry section on Kelley's Island is at northern part of island near glacial grooves (Kelley's Island quadrangle). Section is about 53 ft. thick, all in Columbus limestone. Described by Stauffer (1909, p. 139).
15. *Rushsylvania Quarry.* Abandoned quarry is on the George J. Ansley farm $1\frac{1}{2}$ miles east of Rushsylvania, Rush Creek Township, Logan County (East Liberty quadrangle). Section includes some 15 ft. of Columbus limestone; described by Stauffer (1909, p. 108).
16. *Northwood Quarry.* Section is in abandoned quarry on the Roberts farm, $2\frac{1}{2}$ miles southwest of village of Northwood and $1\frac{1}{2}$ miles south of State Route 274, in McArthur Township, Logan County (East Liberty quadrangle). Section includes about 16 ft. of Columbus limestone.
17. *Bellefontaine quarry.* Bellefontaine quarry section is south of Toledo and Ohio Central Railroad on west edge of Bellefontaine, Logan County (Bellefontaine quadrangle). Section includes about 25 ft., lowest 3 ft. being Lucas dolomite and remainder Columbus limestone. Described by Stauffer (1909, p. 103).
18. *Grubb Quarry.* Grubb quarry is on Raymond Road about half a mile east of Zanesfield, Jefferson Township, Logan County (East Liberty quadrangle). Section includes about 10 ft. of Columbus limestone. Described by Stauffer (1909, p. 103).
19. *East Liberty Quarry.* Quarry, owned by National Lime and Stone Company, is on State Route 33, $1\frac{1}{2}$ miles southeast of East Liberty, Perry Township, Logan County (East Liberty quadrangle). Section includes about 40 ft. of Columbus limestone and the contact with Ohio shale. Described by Stauffer (1909, p. 106).
20. *Sharpe Quarry.* Quarry, abandoned, is on north side of Middlesburg, Zane Township, Logan County (East Liberty quadrangle). Section includes about 19 ft. of Columbus limestone. Described by Stauffer (1909, pp. 106-107).
21. *Piatt Quarry.* Quarry is located a third of a mile south of Machchee Creek on east side of Ludlow Line Road, about 2 miles east of West Liberty in Monroe Township, Logan County (East Liberty quadrangle). Section exposed includes about 23 ft. of Lucas dolomite and about 3 ft. of Columbus limestone. Described by Stauffer (1909, pp. 100-101).
22. *Cable Section.* Section is near State Route 290 half a mile south of Pennsylvania Railroad and $1\frac{1}{2}$ miles west of Cable, Wayne Township, Champaign County (Mechanicsburg quadrangle). Section extends along a run to east of road on Powers farm. It consists of lower part of Columbus limestone, including a fossiliferous chert. Described by Stauffer (1909, pp. 98-99).
23. *Silica Quarry.* Section is exposed in west quarry of France Stone Company and south and north quarries of Medusa Portland Cement Company, Silica, Lucas County (Sylvania quadrangle). Section includes approximately 65 ft. of Columbus(?) Dundee limestone. Described by Ehlers, Stumm and Kesling in the guidebook for The Geological Society of America, Detroit meeting (1951, pp. 17-18).

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General Biology. W. H. Johnson, R. A. Laubengayer and L. E. Delaney. Henry Holt and Company, New York. 1956. x+618 pp. \$6.95.

The concise coverage of up-to-date key facts and principles of biology on a simple plane is a particular outstanding feature of this book. These fundamentals are clearly presented by means of lucid text and illustrative diagrams that are both striking and realistic. A good balance is maintained in the treatment of representative plants and animals. In most cases the general arrangement of contents is designed so that laboratory and classroom work can easily be correlated.

The above features are representative of some of the major objectives set forth in the preface which are well attained. It is the opinion of the reviewer, however, that infectious diseases, immunity, etc. should be discussed together in a single chapter rather than being scattered throughout several chapters as is true in this publication. The M and N blood types should at least be mentioned in the discussion of blood groups. Otherwise, this book should be generally suited as a text for beginning students of biology at the college level, for which it is intended.

GEORGE HULL, JR.

Laboratory Manual for General Biology. W. H. Johnson, R. A. Laubengayer and L. E. Delaney. Henry Holt and Company, New York. 1956. x+174 pp. \$2.75.

This manual, intended to serve as a guide for beginning students of biology at the college level, is divided into thirty-two units, each designed for a three-hour laboratory period. The organization follows that of the textbook by the same authors. In general, the materials selected for observations are suitable for the promotion of an understanding of methods, techniques, and fundamental principles of biology on the studies covered. A list of "materials and equipment needed" is given at the beginning of each unit. Directions for individual observations and demonstrations, to be set up by the instructor, are clear and concise. Directions for special preparations are given in the appendix. Most of the exercises include drawings to be labeled by the student.

In keeping with the above features, this manual should be generally appropriate for the purpose given. However, the reviewer feels that certain omissions or incomplete coverage may limit its usefulness. These include omission of exercises on the skeletal system of vertebrate animals, the classification of plants involving the use of a key, and experiments on blood other than the study of cells. It is also felt that a more complete coverage of animal types would be desirable, though this feeling may be simply a symptom of the reviewer's zoological background.

GEORGE HULL, JR.

Your Career in Physics. *Philip Pollack.* E. P. Dutton and Co., New York. 1955. 127 pp. \$2.75.

This little book is designed for two purposes. The first is to interest high school graduates in following a course of study leading to a career in physics. The second is to acquaint high school counsellors with the requirements for successful work as a professional physicist and to show them some of the opportunities which are now available.

Briefly, Mr. Pollack tries first to show the place of physics and the physicist in the world today. Then he outlines the mental, personality, and professional requirements for successful work in this field. These are followed by short discussions of the opportunities now existing in such fields as electronics, nucleonics, optometry and optical engineering, aeronautical research, biophysics, chemical physics, etc.

An appendix gives an extensive bibliography on the material covered in this book. There is also a list of colleges and universities offering programs in the fields covered. A list showing pay scales in government, university and industrial positions is given. Unfortunately, these data are for about 1951 and do not make very interesting reading when compared with the pay scales existing today.

Mr. Pollack took on a big assignment and in such a brief exposition, omissions must be made and many things considered only in terms of generalities. It is probably a good thing for an outsider to give such a nontechnical description of physics and physicists.

EDWARD S. FOSTER, JR.

Medical Effects of the Atomic Bomb in Japan. *A. W. Oughterson and Shields Warren, Editors.* McGraw-Hill Book Co., New York. 1956. xvi+477 pp. \$8.00.

This authoritative and comprehensive presentation of the effects of the atomic bomb explosions over Hiroshima and Nagasaki is based on the six volume report of the Joint Commission for the Investigation of the effects of the Atomic Bomb in Japan. Most of the data have already been published in various specialty journals, but their incorporation in one book is a convenience for which students of this subject will be grateful.

The injurious effects of both bombs were similar and may be grouped as the result of mechanical trauma, burns, and ionizing radiation. The devastating effect of the blast is illustrated by numerous photographs. The resultant injuries were largely due to flying glass and falling debris. More serious injuries were seldom seen because the victims were killed by fires that swept the cities before rescue operations could be started.

Thermal effects among survivors were usually of the "flash" type, the result of an extremely high temperature acting for only about 3 seconds. The infra-red spectrum was strongly represented. In Hiroshima flash burns occurred to a distance of 3 miles; within 1.2 miles these burns were usually of the third degree.

The effects of the ionizing radiation (largely gamma rays) closely resembled those produced experimentally by total body irradiation of animals with x-rays. In many persons nausea and vomiting occurred within a few hours of exposure. Destruction of blood forming tissues, e.g., lymphnodes and bone marrow, led to a breakdown of defense mechanisms with resultant local and generalized infections followed by death. Ulceration of the gastrointestinal tract as well as wide spread hemorrhages in the skin and viscera were a common finding.

No brief review can give an adequate account of the scope and rich detail incorporated in this book. Although some portions can be best appreciated by specialist, e.g., the section on pathology, the book is strongly recommended for use as collateral reading for high school and college students in general science courses. Civil defense personnel will find the book invaluable, as will all those interested in the problems of radiology.

HANS G. SCHLUMBERGER

Electrical Interference. *A. P. Hale.* Philosophical Library, Inc., New York. 1956. vii+122 pp. \$4.75.

As the author states, the literature on interference is scattered and scarce. The present monograph helps to fill the need. Although the principal message of the book is a discussion of the causes and remedies of electrical interference in radio and television reception, the subject is presented in sufficiently general terms to answer many of the problems of the laboratory worker who deals with low level, low frequency electrical information.

Conducted and radiated interferences are both dealt with in general and in practical terms. Specific consideration is given to the interference produced by various common electrical appliances.

This small volume will be of value to scientists who must handle their own problems of interference suppression.

RICHARD W. STOW

ENROLL A NEW MEMBER

The Ohio Academy of Science was organized on December 31, 1891, at Columbus, was incorporated on March 12, 1892, and became affiliated with the American Association for the Advancement of Science early in 1920. Its membership has grown from 59 charter members to more than 1200. The membership is representative of the educational and scientific institutions of the State and includes quite a number of persons outside the State.

AIMS—According to the Constitution: "The objectives of this Academy shall be the stimulation of interest in the sciences, recognition of merit, promotion of research, improvement of instruction in the sciences, and the dissemination of scientific knowledge." In addition to research and publication, the Academy aids in securing legislation which is favorable to scientific projects, as conservation, topographic and geologic survey, and in other important scientific projects.

MEMBERSHIP—Membership is open to all persons interested in science. Members engaged in scientific work may be elected "fellows." Each member receives *The Ohio Journal of Science* and the publications of *The Ohio Biological Survey* for the regular annual dues of \$3.00. Institution and corporation memberships are open to organizations in the state which are interested in science and in the support of the objectives of the Academy.

SECTIONS—Each member is enrolled in one section for voting purposes, but is privileged to participate in the program of any section. To avoid excessive subdivision into sections as new fields of research develop, symposia which may cut across several fields of interest are scheduled at the annual meeting at hours which permit attendance of persons from various sections. Sections are listed below.

- | | | |
|----------------------------|-----------------------|----------------------------|
| A—Zoology | D—Medical Sciences | H—Science Education |
| B—Plant Sciences | E—Physics & Astronomy | I—Anthropology & Sociology |
| A B—Subsection on Genetics | F—Geography | J—Conservation |
| C—Geology | G—Chemistry | |

MEETINGS—Annual meetings are held at a time and place fixed by the Executive Committee and the Council on the basis of invitations extended by educational institutions presented at the previous annual meeting. A regional plan is followed, so all areas of the state are covered over a period of several years. In addition to the program of scientific addresses and papers, field trips are frequently arranged.

OFFICIAL ORGAN—From 1892 to 1903, the *Journal of the Cincinnati Society of Natural History* and the technical series of *Bulletins of the Ohio Experiment Station* were the official organs of the Academy; in 1903 the *Ohio Naturalist* was made the official organ and continued as such until 1915 when the *Ohio Journal of Science* became the official organ. Its columns are open to members of the Academy for special contributions, subject to acceptance by the Editorial Board. Articles in all scientific areas appear in the *Journal*.

RESEARCH FUND—From 1898 to 1922, through the generosity of M. Emerson MacMillan, of New York, a fund was available annually for encouragement of research among the Academy members. An accumulation from this grant together with the annual grant from the A.A.A.S. makes grants for research available to Academy members. This fund is administered by a committee known as the Trustees of the Research Fund.

INFORMATION—Requests for information concerning any part of the Academy program should be addressed to the Secretary, who will either send a reply or will forward the request to the proper person for reply. The current Secretary is:

DR. R. W. DEXTER, Kent State University, Kent, Ohio.

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